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To promote inter-disciplinary research in the field of agriculture and provide a forum for expressing views on policies and programmes relating to agricultural development

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EFFECT OF INTERCROPPING, PHOSPHORUS LEVELS AND BIO-FERTILIZERS ON THE PERFORMANCE OF BLACKGRAM (*VIGNA MUNGO*)

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Abstract

A field experiment was carried out at the farm of the Amar Singh Post Graduate College, Lakhaoti during *kharif* 2003 and 2004 to study the performance of blackgram under sole and intercropping, phosphorus nutrition and bio-fertilizers. The treatments consisted of combinations of 2 cropping systems *viz.* sole blackgram and blackgram + pigeonpea in 1:1 ratio under additive series; 3 levels of phosphorus *viz.* 0, 30 and 60 kg P_2O_5 /ha and 3 levels of bio-fertilizers viz. control, *Rhizobium* and *Rhizobium* + phosphate solubilizing bacteria (PSB) in factorial randomized block design replicated thrice. The results indicated that the growth and yield parameters, and were superior in sole blackgram as compared to intercropping with pigeonpea. The increasing levels of phosphorus and combination of *Rhizobium* + PSB significantly improved all the growth and yield attributes and yield of blackgram. Total N, P and K uptake were higher with sole blackgram. Phosphorus levels and bio-fertilizers too recorded significant increase in the total N, P and K uptake. Available status of N, P and K soil too influenced by the different treatments.

Key words : Bio-fertilizers, blackgram, economics, intercropping, phosphorus, pigeonpea.

The availability of pulses over the years has been decreasing alarmingly due to more emphasis on the cereal and commercial crops' cultivation. The per capita availability of pulses has dropped from a high of 70 g/capita/day to <30 g/capita/day in 2004 (DES, 2004). Since pulses constitute a major source of protein for a vast majority of population in India increasing their production should be a national priority. Blackgram is an important short duration legume crop which is capable of fitting well in many cropping systems. Its intercropping with wider row crops, proper nutrition, use of low cost inputs like bio-fertilizers will help in popularizing its cultivation with no additional financial burden on the farming community. This experiment was carried out to examine the performance of blackgram grown in sole and intercropping with pigeonpea under varied levels of phosphorus and bio-fertilizers.

Materials and Methods

An experiment was conducted at the Agronomy Research Farm, Amar Singh College, Lakhaoti, and Bulandshahr (U.P.) during *kharif* season of 2003 and 2004 to study the effect of intercropping of blackgram with pigeonpea vis-à-vis its sole cropping under 3 levels of phosphorus and 3 combinations of bio-fertilizers. The soil of the experimental field was sandy loam in texture, well drained and of medium fertility and slightly alkaline in reaction (pH 7.5). It was low in organic carbon (0.39%), medium in phosphorous (10.56 kg/ha) and high in potassium (186 kg/ha) content. The climate during the experimental period during both the years of experimentation was normal with no major incidence of pests or disease problem. The treatments comprised of two cropping systems viz. sole blackgram and blackgram + pigeonpea in 1:1 ratio under additive series, three phosphorus levels viz. 0, 30 and 60 kg P_2O_5 /ha and three bio-fertilizers viz. untreated control, seed treatment with *Rhizobium* alone and combined inoculation of *Rhizobium* and phosphate solubilizing bacteria (PSB). These were tried in factorial randomized block design replicated thrice. Blackgram var. 'Type 9' and pigeonpea var. 'Pusa 33' were used as test crops. The sole blackgram was sown at 50 cm rows while under intercropping it was sown in between the rows of pigeonpea raised in rows of 50 cm wide. The phosphorus through single super phosphate as per the treatments and urea at the rate 20 kg/ha were applied as basal before sowing. The seeds of blackgram were treated with appropriate strains of *Rhizobium* and PSB before sowing. Gap filling and thinning excess plants was done 10 days after sowing on emergence of seedlings. All the important growth parameters were recorded and statistically analyzed as per the analysis of variance technique for factorial randomized block design. The economics for the crops were worked out using the prevailing market rates for both the inputs and the produce. The N, P and K uptake and their available status in soil were estimated using standard procedures.

RESULTS AND DISCUSSION

Growth attributes

The cropping systems did not have significant effect on the plant height of blackgram, while the branches per plant and drymatter accumulations were higher with sole blackgram as compared to intercropped. It may due to competition of pigeonpea for the space and resources. Increasing levels of phosphorus increased the plant height, branches per plant and drymatter accumulation upto 60 kg P_2O_5/ha, like wise 30 kg P_2O_5/ha too recorded significantly higher values over the control. It clearly demonstrated the need of optimum doses of phosphorus for better growth and development of blackgram. The seed inoculation with *Rhizobium* alone and *Rhizobium* + phosphate solubilizing bacteria (PSB) too increased all the growth attributes significantly over the untreated control. This may be ascribed to their effect in increasing the nodulation and phosphorus availability to the growing crop.

Yield attributes

The number of pods/plant were significantly affected by the intercropped pigeonpea in blackgram. Sole blackgram recorded higher pod/per plant in both the years. The number of pods /plant also showed similar trend. The test weight was unaffected by the cropping systems.

Table 1. Plant height, number of branches/plant and drymatter accumulation of blackgram as influenced by cropping systems, phosphorus levels and bio-fertilizers

Treatment	Plant height (cm)		Branches/plant		Drymatter (g/plant)	
	2003	2004	2003	2004	2003	2004
Cropping system						
Sole blackgram	52.30	40.24	6.72	6.47	22.66	19.89
Blackgram + pigeonpea	51.64	42.53	6.37	6.33	15.59	12.77
SEm±	1.27	1.29	0.050	0.060	0.32	0.30
CD (P=0.05)	NS	NS	0.160	NS	1.12	1.27
Phosphorus levels (kg P_2O_5/ha)						
0	42.15	32.65	6.13	5.92	14.84	12.58
30	54.18	43.67	6.63	6.50	20.34	17.43
60	59.58	47.85	6.9	6.78	22.20	18.98
SEm±	1.58	1.56	0.050	0.070	0.35	0.33
CD (P=0.05)	4.75	4.69	0.150	0.210	1.05	1.00
Biofertilizer						
Control	45.62	34.55	5.68	5.55	16.54	13.78
Rhizobium	52.55	42.93	6.75	6.62	19.53	16.64
Rhizobium + PSB	57.75	46.68	7.23	7.03	21.33	18.57
SEm±	1.57	1.58	0.060	0.080	0.40	0.36
CD (P=0.05)	5.42	5.47	0.200	0.260	1.37	1.26

The phosphorus levels increased the number of pods/plant, pod length and number of seed/pod significantly upto 30 kg P_2O_5/ha over control. It was at par with 60 kg P_2O_5/ha. The test weight was unaffected by the phosphorus levels. Seed treatment with *Rhizobium* and *Rhizobium* + phosphate solubilizing bacteria (PSB) recorded significantly higher yield attributes except the test weight which was at par with different bio-fertilizer treatments in both the years. The improvement in yield parameters in bio-fertilizers treatment may due to their positive influence on the growth attributes and better translocation of photosynthates to the reproductive organs.

Yield

The sole crop of blackgram recorded the highest seed and stover yield in both the years. It may be attributed to the optimum growing space to the growing crop unlike in intercropped blackgram where it had to compete for the space and other inputs (Tomar *et al.*, 1997). The harvest index was however not influenced by the intercropping systems. The phosphorus levels increase the seed yield of blackgram significantly. Application of each successive dose of phosphorus recorded significantly higher seed yield over previous level upto 60 kg P_2O_5/ha, in both the years. The stover yield also showed the similar trend. The harvest index was however increased significantly only upto 30 kg P_2O_5/ha. Phosphorus being important for several important physiological functions and constituent of several compounds, plays a significant role in increasing the productivity of the crop. Mishra (1993) also reported increased yield due to phosphorus nutrition. The bio-fertilizers also had significant influence on the seed yield and stover yield of blackgram. While the harvest index was not influenced significantly by the bio-fertilizers. Increase in seed yield due to inoculation with *Rhizobium* and phosphate solubilizing bacteria (PSB) has also reported by Sharma and Vyas

Table 2. Yield attributes of blackgram as influenced by cropping systems, phosphorus levels and bio-fertilizers

Treatment	2003				2004			
	No. of pods/ plant	Pod length (cm)	No. of seeds/ pod	Test weight (g)	No. of pods/ plant	Pod length (cm)	No. of grains/ pod	Test weight (g)
Cropping system								
Sole blackgram	13.77	7.82	10.93	30.52	10.88	7.14	9.06	30.27
Blackgram + pigeonpea	11.87	7.64	10.07	30.19	8.90	6.94	8.11	29.36
SEm±	0.19	0.09	0.13	0.63	0.18	0.11	0.16	0.57
CD (P=0.05)	0.66	NS	0.46	NS	0.63	NS	0.51	NS
Phosphorus levels (kg P_2O_5/ha)								
0	11.30	7.43	9.20	29.20	8.52	6.43	7.43	28.67
30	13.37	7.86	10.88	30.53	10.37	7.22	8.92	29.98
60	13.78	7.90	11.43	31.33	10.78	7.47	9.43	30.80
SEm±	0.24	0.11	0.15	0.75	0.22	0.13	0.18	0.66
CD (P=0.05)	0.71	0.33	0.45	NS	0.65	0.39	0.54	NS
Biofertilizer								
Control	9.52	6.72	9.01	29.43	6.58	6.07	7.27	28.74
Rhizobium	13.47	7.98	11.09	30.90	10.72	7.38	8.83	30.14
Rhizobium + PSB	15.47	8.45	11.40	30.73	12.37	7.67	9.68	30.57
SEm±	0.23	0.11	0.16	0.78	0.22	0.14	0.18	0.69
CD (P=0.05)	0.81	0.39	0.56	NS	0.77	0.48	0.62	NS

(2001). This is mainly due to their positive influence on the growth and yield parameters and subsequently resulting in increased seed yield.

N, P and K uptake and their available status in soil

The various treatments imposed had significant impact on the total N, P and K uptake by blackgram and the their status in the soil after the harvest. The sole crop under bio-fertilizers recorded the highest uptake as compared to intercropped blackgram. This may attributed to the fact that the crop yield was lesser in intercropped blackgram. Likewise application of phosphorus too recorded higher uptake of N and P upto 60 kg P_2O_5/ha and K upto 30 kg P_2O_5/ha. It may due to the fact that potassium is not much influenced by the phosphorus treatments. Sarwagi *et al.* (1998) also reported higher uptake in N and P due to phosphorus fertilization. The bio-fertilizers too increased the N, P and K uptake significantly over the control. The *Rhizobium* + phosphate solubilizing bacteria (PSB) recorded significantly higher uptake over other treatments. The N, P and K status in soil was influenced differentially by different treatments. The cropping systems had significant impact on the available P status in soil after harvest where the intercropping systems recorded higher P status over sole cropping of blackgram. Similarly, P status also increased with increasing level of phosphorus upto 60 kg P_2O_5/ha over other treatments. Both N and K status were not influenced by the cropping systems or phosphorus levels. The seed inoculation with Rhizobium and Rhizobium + phosphate solubilizing bacteria (PSB) recorded higher N and P status, while the K was unaffected the bio-fertilizers. This is mainly due to the relationship of these bio-fertilizers with N and P only and not with K.

Table 3. Seed yield, stover yield and harvest index of blackgram as influenced by cropping systems, phosphorus levels and bio-fertilizers

Treatment	Seed yield (kg/ha)		Stover yield (kg/ha)		Harvest index (%)	
	2003	2004	2003	2004	2003	2004
Cropping system						
Sole blackgram	766	656	2640	2175	21.17	20.62
Blackgram + pigeonpea	606	514	1920	1419	20.75	21.49
SEm±	14	23	43	23	0.26	0.38
CD (P=0.05)	44	73	150	81	NS	NS
Phosphorus levels (kg P_2O_5/ha)						
0	528	513	1876	1481	17.28	16.35
30	740	599	2368	1843	22.87	23.51
60	791	644	2597	2067	22.73	23.31
SEm±	15	11	49	25	0.30	0.45
CD (P=0.05)	48	37	146	77	0.910	1.350
Biofertilizer						
Control	590	445	1830	1504	20.90	20.49
Rhizobium	710	631	2419	1871	20.75	21.02
Rhizobium + PSB	759	680	2592	2017	21.23	21.66
SEm±	15	12	53	29	0.31	0.47
CD (P=0.05)	46	38	184	99	NS	NS

Table 4. **Yield attributes of blackgram as influenced by cropping systems, phosphorus levels and bio-fertilizers**

Treatment	Total uptake (kg/ha)						Available status (kg/ha)					
	N		P		K		N		P		K	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Cropping system												
Sole blackgram	65.55	53.38	5.73	4.22	27.89	20.54	194.6	196.7	8.92	10.27	232	245
Blackgram + pigeonpea	47.90	35.37	4.09	3.01	20.17	13.60	196.0	198.9	9.88	10.92	234	255
SEm±	1.06	0.88	0.08	0.06	0.500	0.29	1.1	1.5	0.22	0.14	5.37	6.31
CD (P=0.05)	3.68	3.05	0.27	0.23	1.730	1.04	NS	NS	0.67	0.43	NS	NS
Phosphorus levels (kg P_2O_5/ha)												
0	41.50	31.95	3.28	2.39	20.61	14.97	191.8	194.4	8.24	9.57	229	240
30	60.91	47.39	5.39	3.83	25.51	17.41	195.7	198.6	9.44	10.38	234	250
60	67.76	53.78	6.07	4.62	25.98	18.84	198.4	200.4	10.52	11.86	236	260.0
SEm±	1.09	0.94	0.08	0.07	0.560	0.37	3.2	3.4	0.52	0.54	5.41	6.31
CD (P=0.05)	3.27	2.82	0.26	0.22	1.700	1.12	NS	NS	1.58	1.63	NS	NS
Biofertilizer												
Control	41.82	33.86	3.80	2.99	17.93	13.93	192.0	194.4	8.58	9.78	226	242
Rhizobium	60.41	46.52	5.09	3.78	25.85	17.69	195.5	198.0	9.35	10.33	235	251
Rhizobium + PSB	67.94	52.74	5.85	4.07	28.32	19.60	198.4	201.0	10.27	11.68	238	257
SEm±	1.30	1.08	0.09	0.08	0.61	0.37	1.2	1.3	0.56	0.56	5.45	6.28
CD (P=0.05)	4.51	3.73	0.34	0.28	2.13	1.27	3.4	3.6	1.59	1.71	NS	NS

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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON PRODUCTIVITY, NUTRIENT UPTAKE AND CHANGES IN SOIL FERTILITY IN RICE (*ORYZA SATIVA*) - WHEAT (*TRITICUM AESTIVUM*) CROPPING SYSTEM

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ABSTRACT

A long-term experiment initiated in 1984 was sampled during 2004-05 and 2005-06 to study the cumulative impact of organic sources, *viz.*, Farm Yard Manure (FYM), wheat straw and green manuring with *Sesbania aculeate* organic-inorganic combinations in rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. Pooled data revealed that substitution of 50% N through FYM and rest 50% NPK through inorganic fertilizers in rice and 100% NPK in wheat removed highest N, P and K from soil and gave significantly higher grain yields of rice (52.72 q/ha), wheat (40.02 q/ha), rice equivalent yield (107.28 q/ha), and net return (Rs. 38, 336/ha) of the system as compared to the treatment receiving 100% recommended dose of NPK through fertilizers in both the crops. However, incorporation of 50% N through G.M. or wheat straw in rice and 100% NPK in wheat exhibited statistical parity with the best treatment. All the organic sources were instrumental in improving bulk density, hydraulic conductivity, aggregations of soil, microbial status and available N content of soil than application of N, P and K alone. Organic carbon status and P-balance in soil positive in all treatments except control and 50% NPK through fertilizer and its accumulation was higher when organic matter was incorporated in the soil. Marginal decline in K-status was observed in all the treatment except cumulative effect incorporation of 50% N through organic sources. All organic sources exhibited cumulative effect resulting in gradual rise in productivity of rice-wheat system over the years.

Key words : Integrated nutrient management, rice-wheat system, productivity, economics

Rice-wheat system plays a significant role in food security, contributing 76% to the total food grain production of the country. This system occupies 9.7 million ha in India (Joshi and Tripathi, 2006). The high cost of fertilizers and unstable crop production requires substitution a part of inorganic fertilizers by locally available recycling has generated a higher importance especially in cereal based cropping systems (Sarkar *et al.*, 1997) . The residual nature of organic source makes them more value based for the whole system as compared to individual crops. With the above facts under consideration, the present investigation was therefore initiated to study the effect of various organic manures and inorganic fertilizer on crop productivity, nutrient removal and soil fertility of rice-wheat system.

MATERIALS AND METHODS

The experiment was conducted in fixed plots under the All India Coordinated Systems Research Project on Cropping Systems at Bihar Agricultural College Farm, Sabour, Bhagalpur during rainy and winter seasons of 2004-05 and 2005-06. The soil during 1984, the starting year of the experiment, was clay loam in texture having bulk density 1.40 g/cm^3, hydraulic conductivity of 0.192 cm/hr, mean weight diameter of soil aggregates 0.44 mm, organic carbon 0.46%, available N 194.0 kg/ha, available P_2O_5 22.0 kg/ha and available K_2O 155.0 kg/ha. The experiment was laid out in randomized block design with 4 replications, consisting of 12 treatment combinations viz., T_1: control (no fertilizer no organic manure); T_2-50% recommended dose of fertilizers (RDF) to both

Table 1. Yields, rice-equivalent yield and economics as influence by integrated nutrient management practices

Treatments		Grain yield (q/ha)		Straw yield (q/ha)		Rice equivalent Yield (q/ha)	Net income	B:C ratio
Rice	Wheat	Rice	Wheat	Rice	Wheat			
T_1, control	control	12.18	7.31	22.22	16.87	22.17	(-) 10,191	(-) 0.38
T_2, 50% NPK	50% NPK	25.79	18.55	39.07	29.32	51.08	6,578	0.23
T_3, 50% NPK	100% NPK	27.13	31.36	41.07	42.97	69.89	17,366	0.59
T_4, 75% NPK	75% NPK	33.85	26.02	45.12	37.75	69.40	17,022	0.58
T_5, 100% NPK	100% NPK	44.98	33.96	59.67	46.67	91.29	30,399	1.00
T_6, 50% NPK + 50% N(FYM)	100% NPK	52.72	40.02	69.36	53.81	107.28	38,336	1.36
T_7, 50% NPK + 25% N(FYM)	75% NPK	48.69	36.46	64.98	50.40	96.61	34,651	1.11
T_8, 50% NPK + 50% N(WS)	100% NPK	50.84	38.22	67.15	52.01	102.96	36,215	1.11
T_9, 75% NPK + 25% N(WS)	75% NPK	47.02	34.71	61.59	47.12	94.35	31,975	1.04
T_{10}, 50% NPK + 50% N(GM)	100% NPK	51.88	39.18	67.82	52.29	105.31	37,399	1.15
T_{11}, 75% NPK + 25% N(GM)	75% NPK	47.91	35.67	63.05	48.20	96.55	33,281	1.08
T_{12}, F.P (70:30 kg NP/ha)	F.P. (80:30:10, NPK/ha)	31.84	27.63	43.11	35.40	69.50	10,811	0.37
CD (p=0.05)		3.72	2.98	4.12	3.92	5.74	3,276	-

FYM - Farm Yard Manure, WS - Wheat Straw, GM - Green Manure.

rice and wheat; T_3-50% RDF to rice and 100% RDF to wheat; T_4-75% RDF to both rice and wheat; T_5-100% RDF to both rice and wheat; T_6-50% RDF + % N through FYM to rice and 100% RDF to wheat; T_7-75% RDF + 25% N through FYM to rice and 75% RDF to wheat; T_8-50% RDF + 50% N through wheat straw to rice 100% RDF to wheat; T_9-75% RDF + 25% N through wheat straw to rice and 75% RDF to wheat; T_{10}-50% RDF + 50% N through green leaf manure to rice and 100% RDF to wheat; T_{11}-75% RDF + N through GLM to rice and 75% RDF to wheat; T_{12}-Farmer's fertilizers practice to rice and wheat (70 kg + 30 kg P_2O_5 + 10 kg K_2O/ha).The rice variety Sita and wheat variety UP262 were used in the experiment. The recommend dose of fertilizers in rice was applied @ 80 kg P_2O_5 and 20 kg K_2O/ha and for wheat @ 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha. The FYM, wheat straw and green leaves of *Sesbania* were analyzed for N content and their required amount was applied 3 weeks before rice transplanting as per treatment to substitute a specified amount of N. The FYM, wheat straw and green manure (*Sesbania*) used in this experiment on an average contained 0.05%0.65% and 0.53% N, respectively. *Sesbania aculeate* crop was grown separately up to 55 days, uprooted, chopped and applied to the respective treatments. All improved package of practices were followed to raise a good crop. For physical, chemical and microbial count, composite samples from all replications were used for analysis. The grain yield data of rice and wheat for all previous years were averaged for every 5 years to examine the yield trends from beginning of experiment. The soil was analyzed after harvest of wheat to monitor the charges in nutrient status over the years.

RESULTS AND DISCUSSION

Grain yield

Grain yields of rice and wheat were highest in the plots which received 50% recommended NPK through fertilizer and 50% N through FYM in rice and 100% recommended dose of fertilizer (RDF) in wheat, which however exhibited statistical equality with the treatments supplied with 50% N through green leaf manure (*Sesbania*) and wheat straw + 50% RDF through inorganic fertilizers in rice and 100% RDF in wheat (T_8 and T_{10}) but these treatments significantly out yielded the treatments having received 100% NPK in both the crops. The plots receiving 25% N , T6 and through FYM, wheat straw and green leaf manure in rice and getting 75% recommended NPK in wheat (T) also helped to raise yield level of rice and wheat but differences were not significant. Higher availability of nutrients because of favourable effect of organic sources might have improved physiological and metabolic functions inside the plant body which in turn laid down the foundation for higher yields in both the crops. The FYM and green leaf manure has advantages over wheat straw perhaps because of fully decomposed FYM before application and fast decomposition of green leaf manure which led to better availability or release of nutrients than wheat straw. These findings are in close agreement with those reported by Bajpai *et al.* (2002). The total grain productivity in terms of rice-equivalent yield was significantly higher under treatment supplied with 50% NPK + 50% N through FYM in rice and 100% NPK in wheat, which however was at par with the plots getting 50% N through GLM and wheat straw + NPK in rice and 100% NPK in wheat. These treatments in its own, turn produced significantly higher rice equivalent yield than 100% NPK in both the crops and substitution of 25% N through organic sources. Thus, saving of 25 to 50% NPK in rice is possible with use of organic manures without affecting the production of rice-wheat system.

Yield trends over years

Pooled data for 5 years (1984-85 to 1988-89) at the start of experiment indicated that plots receiving 100% nutrient through inorganic sources produced significantly higher grain yields of rice and wheat than those receiving nutrient through organic and inorganic combinations (Table 2). Application of moderate doses of organic manures (substituted only 20 to 40 kg N/ha) continuously over the years have demonstrated their favourable effect during 1989-90 to 1993-94. In this period, substitution of 50% N through FYM and green leaf manure showed improvement in grain yields of rice and wheat over application of 100% recommended NPK through fertilizers. During the period of 1994-95 to 1997-98 and 1999-2000 to 2003-04, the effects of moderate doses of organic manures were more pronounced. After lapse of 15 to 20 years, substitution of 50% N through FYM, green leaf manure and wheat straw in rice and 100% recommended NPK in wheat were instrumental in getting significantly higher grain yields of both the crops as compared to treatment receiving 100% recommended NPK through fertilizers. Similar results were reported by Hegde (1998). The maximum increase of 12.20 and 17.84% in grain yields of rice and wheat over mean yields of initial 5 years, was computed when 50% N in rice was substituted by FYM and wheat was fertilized with 100% recommended NPK, followed by plots receiving 50% N through green leaf manure in rice and 100% NPK in wheat having corresponding figures of 10.33 and 13.80 per cent, respectively. It may thus be inferred that productivity of rice-wheat system was sustained with the integrated use of organic-inorganic combinations. However, almost all the treatments showed an improvement in grain yields of both the crops with time except the control. In the control plot, rice and wheat yields reduced by 30.2 and 13.6 per cent during 20 years of experimentation.

Economics

The cost of cultivation was marginally higher when the nutrient was applied in combination, but due to higher grain and straw yields the net return and benefit : cost ratio were also higher in the integrated use of organic and inorganic fertilizers (Table 1). The highest net return of Rs. 38, 336/ha with 1.16 benefit : cost ratio was occured when 50% N rice was substituted by FYM and 100% NPK through fertilizers were applied in wheat, which however, exhibited statistical parity with the treatments supplemented with 50% N through GLM or wheat straw in rice and 100% NPK in wheat but these treatments earned significantly higher net return than those getting 100% recommended NPK in both the crops. These results are in close conformity with the findings of Singh *et al.*, (2006). Who also reported higher profit from rice-wheat system with integrated nutrient management over recommended dose of NPK fertilizers. Both rice and wheat cultivation with out any fertilizer application was not found economical, as it caused loss of Rs. 10,191/ha which might be because of declining in rice and wheat yields (Yadav *et al.*, 1998).

Nutrient uptake

The uptake of N,P and K by rice was the maximum from the treatment supplied with 50% N through FYM and 50% NPK through fertilizers. The treatment next in order and having parity with the treatment taking up the maximum amount nutrients was the one which received green leaf manure and inorganic fertilizer in 50:50 ratio. Uptake of nutrients by wheat and total uptake by both the crops was significantly the maximum in the treatment involving 50% substitution of nutrients through FYM in preceding rice crop but getting 100% NPK in rice-wheat. Higher biomass production due to combined application of organic and inorganic fertilizers may be the most pertinent reasoning for higher uptake of nutrients in the treatments

Table 2. Average grain yield (q/ha) of rice-wheat under integrated nutrient practice in long-term field trial

Treatments		1984-85 to 88-89		1889-90 to 93-94		1994-95 to 98-99		1999-2000 to 2003-04	
Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
T_1, control	control	17.10	9.09	17.73	9.10	12.45	7.62	11.94	7.85
T_2, 50% NPK	50% NPK	27.88	17.75	27.52	18.05	27.44	17.03	27.66	18.83
T_3, 50% NPK	100% NPK	28.24	27.68	28.69	29.74	28.67	26.87	29.40	30.30
T_4, 75% NPK	75% NPK	33.11	24.56	33.26	28.19	33.99	24.15	34.42	26.47
T_5, 100% NPK	100% NPK	4.52	30.46	39.49	31.90	39.62	30.43	41.98	32.05
T_6, 50% NPK + 50% N(FYM)	100% NPK	36.69	29.40	41.33	33.93	44.62	34.62	47.11	37.77
T_7, 50% NPK + 25% N(FYM)	75% NPK	38.00	25.81	40.48	32.18	42.49	30.58	45.28	33.89
T_8, 50% NPK + 50% N(WS)	100% NPK	34.17	27.43	38.31	32.02	42.79	33.63	43.89	36.85
T_9, 75% NPK + 25% N(WS)	75% NPK	36.18	25.09	38.91	30.65	40.82	30.22	4308	32.52
T_{10}, 50% NPK + 50% N(GM)	100% NPK	34.38	27.90	39.52	32.26	43.49	33.94	46.32	36.47
T_{11}, 75% NPK + 25% N(GM)	75% NPK	36.06	25.89	38.67	31.22	40.36	29.68	43.37	32.14
T_{12}, F.P (70:30 kg F.P. (80:30: NP/ha)	FP (80:30:10, NPK/ha)	28.44	17.55	28.77	20.10	28.92	21.34	30.32	24.27
CD (p=0.05)		2.14	2.66	2.83	2.40	3.20	2.66	3.44	2.41

Table 3. Uptake of nitrogen, phosphorus and potassium in rice-wheat system as influenced by integrated nutrient management system practice

Treatments		Rice			Wheat			Rice-wheat system		
Rice	Wheat	N	P	K	N	P	K	N	P	K
T_1, control	control	24.0	6.80	29.7	24.2	3.3	34.5	48.2	10.1	64.2
T_2, 50% NPK	50% NPK	48.3	14.8	54.6	53.5	7.5	64.9	101.8	22.3	119.5
T_3, 50% NPK	100% NPK	51.4	14.2	69.3	85.4	12.6	99.9	136.8	26.8	169.2
T_4, 75% NPK	75% NPK	62.8	16.7	67.6	73.2	10.6	83.5	136.0	27.3	151.1
T_5, 100% NPK	100% NPK	85.0	23.2	93.2	96.1	14.3	109.3	181.1	37.5	202.5
T_6, 50% NPK + 50% N(FYM)	100% NPK	99.2	26.2	112.6	111.2	15.9	132.1	210.4	42.2	244.7
T7, 50% NPK + 25% N(FYM)	75% NPK	91.9	24.3	103.1	102.6	14.3	119.6	194.5	38.6	222.7
T_8, 50% NPK + 50% N(WS)	100% NPK	95.1	25.1	108.1	106.1	14.9	128.4	201.2	40.0	236.5
T_9, 75% NPK + 25% N(WS)	75% NPK	88.6	23.1	98.5	97.4	13.2	114.5	186.0	36.3	213.0
T_{10}, 50% NPK + 50% N(GM)	100% NPK	98.2	25.7	110.2	110.1	14.7	127.4	208.3	40.4	237.8
T_{11}, 75% NPK + 25% N(GM)	75% NPK	90.2	24.6	100.4	101.3	14.0	114.5	191.5	38.6	214.9
T_{12}, F.P (70:30 kg F.P. (80:30: NP/ha)	FP (80:30:10, NPK/ha)	58.6	15.1	68.4	76.9	9.7	84.3	135.5	24.8	152.7
CD (p=0.05)		4.31	1.35	3.92	3.60	1.20	5.29	7.43	2.08	8.20

referred above. Similar observations were reported by Das *et al.* (2003).

Physical properties of soil

Organic sources viz, FYM , wheat straw and green leaf manure with Sesbania used to substitute either 50 or 20% N in rice crop were effective in bringing about marked improvement in bulk density, hydraulic conductivity and mean weight diameter of soil aggregates (Table 4). Wheat straw followed by FYM was the best in the development of favourable bulk density and hydraulic conductivity. The FYM was effective in the formation of larger aggregates, followed by wheat straw and green manure crop in descending order. The quantity of biomass added to the soil through different organic sources and the quality of end product of decomposition of organic matter capable of imparting bonding effect on soil particles might have been responsible to improve aggregation, porosity and humus which, in turn might have induced favourable effect on physical properties of soil. Formation of certain polysaccharides during decomposition of organic residues by microbial activity as well as the cementing action of bacteria and fungi might also be one of the reasons for improving physical proportions of soil under organo-inorganic combination. The results confirm the findings of Pathak *et al.* (2005).

Chemical properties of soil

Addition of organic matter was helpful in improving status of organic carbon, available N,P and K in soil during experimentation. FYM was instrumental in build up of significantly highest organic carbon content of 0.46 to 0.77%. The green manure followed by wheat straw were the next. Application of even the half of the recommended dose of inorganic fertilizers maintained the original organic carbon level. The control plot exhibited drop in organic carbon content. Incorporation of organic amendments induced an increasing effect on organic carbon

Table 4. Physical, chemical and biological properties as influenced by integrated nutrient management practice

Treatment	Physical				Chemical			Microbial population x 10^4/g of soil			
	B.D (g/cc)	H.C (cm/hr)	MWD	O.C%	Available N	Available P_2O_5	Available K_2O	Bacteria	Actinomycetes	Fingi	Total
T_1	1.56	0.170	0.38	0.40	128.8	12.20	123.1	208.4	93.0	19.4	321.2
T_2	1.50	0.176	0.42	0.46	151.2	19.01	127.3	278.2	122.4	36.8	437.4
T_3	1.51	0.182	0.43	0.52	162.4	30.23	130.3	270.5	140.6	45.3	456.3
T_4	1.49	0.189	0.45	0.51	168.7	29.31	138.4	302.1	149.9	39.5	495.5
T_5	1.45	0.196	0.49	0.56	181.5	38.93	140.3	291.9	167.5	41.7	501.1
T_6	1.40	0.245	0.68	0.77	231.3	47.27	165.6	395.5	201.9	56.4	653.8
T_7	1.43	0.235	0.56	0.68	211.8	43.18	149.2	378.3	194.9	51.8	625.0
T_8	1.36	0.249	0.65	0.71	218.2	40.19	169.3	288.1	147.3	38.9	474.3
T_9	1.39	0.238	0.58	0.65	196.0	39.05	146.3	290.7	118.3	29.6	438.8
T_{10}	1.41	0.240	0.60	0.74	226.1	45.11	169.4	394.3	119.8	67.3	661.4
T_{11}	1.45	0.230	0.55	0.66	208.4	40.76	147.4	357.0	165.3	44.0	566.3
T_{12}	1.52	0.190	0.47	0.48	152.4	27.02	128.8	236.9	95.3	23.4	355.6
Initial 1984-85	1.40	0.192	0.44	0.46	194.0	23.00	155.0	-	-	-	-

BD-Bulk density; HC-Hydraulic conductivity; MWD-Mean weight diameter

status might due to improvement of physical and biological properties of the soil (Nayyar, 2002).

Application of inorganic fertilizers resulted in the sharp reduction in the available N. However, the highest available N in soil was noted in the plots treated with FYM followed by green leaf manure and wheat straw might be the out come of biological transformation i.e. mineralization of elements (Subbarao, 1999).

There was substantial build up in available P_2O_5 in all the treatments except the control and the treatment having 50% NPK through fertilizer in both the crops. However, the maximum build up was observed more in the plots supplied with FYM followed by green leaf manure and wheat straw. Build up of available P_2O_5 even in the plots getting only inorganic fertilizers may be ascribed the lower uptake than the amount added externally. Increase in available P_2O_5 in organo-iorganic combinations may be due to the mineralization of organic matter accompanied by the release of appreciable quantities of CO_2 which when dissolved in water, forms carbonic acid which is capable of decomposing certain primary minerals which might increased availability of P_2O_5. The results are in close conformity with findings of Hussain *et al.* (1998), Raju and Reddy (2000).

A marginal decline in available K status from its initial level was observed in all the treatments except plots getting 50% N through organic sources. The plots getting 50% N through wheat straw exhibited higher build up of available K in soil closely followed by FYM (Table 4). Higher K_2O content in wheat straw than other sources might have been the possible reason for higher residual K in the soil. At the current level of productivity, the K uptake must have been much higher than its application, but still the charges in available K_2O after continuous rice-wheat cropping was of smaller magnitude probably because the crop requirement of K was largely met with non-exchangeable pool of soil (Swarup and Singh, 1989).

Biological properties of soil

Soil biologia as envisaged through the population of bacteria, actinomycetes and fungi in experimental plot (Table 4) showed that substitution of inorganic fertilizers through organic manure either in the proportion of 50% or 25% were instrumental in raising the microbial density significantly. Pronounced effects of FYM and green manure on all the microbes may be explained in the light of the fact that both the amendments were of low C:N ratio, which induced a positive effect on microbial community. The availability of higher organic carbon and available N under the influence of these amendments might have enhanced the count of bacteria, actinomycetes and fungi whereas, the effect of wheat straw was not so notable due to its higher C:N ratio. Increasing doses of inorganic fertilizers were also helpful in increasing microbial population which have been result of profile root growth and higher rhizosphere effect (Subbarao, 1999).

The study indicated that application of moderate dose of FYM (40 to 80 q/ha), wheat straw (30 to 60 q/ha) and green manure with Sesbania (36 to 76 kg/ha) in rice can reduce the recommended dose of inorganic fertilizer from 25 to 50 for their yield stability, soil health and sustainability in rice-wheat cropping system to maintain productivity.

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GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS IN EXOTIC LINES OF CABBAGE (*BRASSICA OLERACEA* VAR. *CAPITATA* L.) UNDER NORTH WESTERN HIMALAYAS

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ABSTRACT

The genetic variability, correlation and path analysis in twenty five exotic lines of cabbage (*Brassica oleracea* var. *capitata* L.) under mid hills (during 2003 and 2004) revealed that all the characters under study contributed up to 99 per cent towards the variation in yield. This indicated the adequacy of the characters while resorting to the selection in cabbage. The genotypic correlation coefficients were higher in magnitude than the corresponding phenotypic ones, thereby suggesting strong inherent association between various characters studied. The marketable head yield had positive and significant association with gross weight, net weight of head, non wrapper leaves and compactness of head thereby indicating that these traits had certain inherent relationships with yield. The net weight of head had the highest direct effect on head yield followed by compactness, marketable head (%), stalk length and non-wrapper leaves while, gross weight and head shape contributed indirectly towards head yield via net weight and gross weight, respectively. Thus, the present study suggests that net weight of head should be given utmost importance in selection programme aimed at breeding high yielding cabbage varieties. Due importance must also be given to compactness, marketable head (%), non-wrapper leaves and gross weight in the selection programme.

Key words : Cabbage, path analysis, genotypic phenotypic, correlation coefficients.

Cabbage (*Brassica oleracea* var. *capitata* L.) is one of the most important vegetables in their world. It occupies the pride place among cole crops due to its delicious taste, flavor and nutritive value. In Himachal Pradesh, cabbage is a major off-season vegetable covering am area of about 2195 ha with the production of 66.311 tones (Anonymous, 2004). Cabbage grown as an off-season vegetable in mid and high hills of the state during summer months generally brings lucrative returns to the farmers. The major constraints in increasing and stabilizing cabbage production and prices are the lack of high yielding and compact headed varieties. At present only four cultivars of cabbage viz. 'Golden Acre', 'Pusa Mukta', 'Pride of India' and 'Pusa Drum Head, are on the recommended list for cultivation not only in Himachal Pradesh but throughout the country since long and these have a tendency to produce loose and unmarketable heads in large proportion during summer months in the hills. In spite of its economic importance, only a limited research on varietal development has been carried out in India on account of crossing work and seed production possible in the high hills only. The presence of sufficient genetic variability is the basic requirement in the success of a breeding programme. It is equally imperative to assess the relative proportion of genetic and environmental components of variability, nature and extent of association between different yield attributes and relative importance of direct and indirect influence of each of the component traits on yield so as to improve the plant as a whole rather than the individual traits. Thus, an attempt was made to generate information in respect of genetic parameters of some exotic lines in cabbage under North Western Himalayas.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Farm of Himachal Pradesh Krishi

Vishvavidyalaya, Hill Agricultural Research and Extension Centre, Bajaura, Kullu (33° N, 77° E and 1090 m a.m.s.l.) during 2003 and 2004. Twenty five genetically diverse genotypes of exotic cabbage viz., EC 481002, EC 481006, EC 481007, EC 481015, EC 481016 EC 481019, EC 481022, EC 481030, EC 481031, EC 481033, EC 481034, EC 481035, EC 481038, EC 481039, EC 481040, EC 481045, EC 481055, EC 481056, EC 481058, EC 481059, EC 481060, EC 481067 (Horticultural Research International, Wellsborne, UK), KGAT-III (CSKHPKV, Palampur), 'Golden Acre' and 'Pusa Mukta' (IARI, Katrain) were grown in randomized block design with three replications. Each genotype was planted in a plot of 2.25 x 1.8 cm with a spacing of 45 cm and 45 cm between and within rows, respectively. The observations were recorded on ten competitive plants for days to maturity, gross weight/plant (g), net weight of head/plant (g), marketable head (%), marketable head yield/ha, number of leaves/plant, stalk length (cm), shape of head, compactness of head and harvest index. The mean values pooled over years were used for standard statistical analysis. The genotypic and phenotypic coefficients of variation, broad sense heritability (h^2) were computed according to Singh and Chaudhary (1985). Genetic advance was estimated by Johnson *et al.* (1955). Genotypic and phenotypic correlation coefficients were calculated as suggested by Al-Jibouri *et al.* (1958) and path analysis by Dewey and Lu (1959). The compactness of head was worked out as methods suggested by Pearson (1931). Shape index of head was worked out by dividing the polar diameter with equatorial diameter. Heads with shape index values more than 1.0 were categorized as pointed, 0.8 to 1.0 round and below 0.8 as flat.

RESULTS AND DISCUSSION

Significance of mean squares due to genotypes for all the traits indicated existence of high degree of variability in the material (Table 1). The genotypic (GCV) and phenotypic coefficients of variation (PCV) expressed in per cent points (Table 2) were comparatively high for gross for gross weight (30.33, 31.36) and net weight of head (26.34, 29.22), respectively. The magnitude of PCV was more than GCV in all the traits, indicating the role of environment (heterogeneity in soil fertility status or other unpredictable factors) in the expression of traits under observation. The characters showing high GCV possessed better potential for the improvement through selection. Similar projections have also been made by Sharma and Verma (2000) and Thakur and Thakur (2002). The estimates of variability act as a predictive instrument in expressing the reliability of phenotypic value. It, therefore, helps the plant breeder to make selection for a particular character when heritability is high.

The genetic advance is a useful indicator of the progress that can be expected as a result of exercising selection on the pertinent population. In the present study, most of the characters

Table 1. Analysis of variances for different characters in cabbage (pooled data)

Characters (Mean squares)	Source of variation		
	Replications	Genotypes	Errors
Days to marketable maturity	0.813	344.628*	20.811
Gross weight/plant	0.011	0.705*	0.006
Net weight of head/plant	0.001	0.224*	0.006
Marketable heads (%)	13.625	201.654*	15.052
Marketable head yield (q/ha)	629.500	36841.116*	966.704
Non-wrapper leaves/plant	0.620	26.098*	1.547
Stalk length	0.427	26.365*	1.949
Shape of head	0.001	0.109*	0.001
Compactness of head	7.992	434.592*	6.611
Harvest index	107.125	202.282*	33.691

*P=0.05

Table 2. Mean and genetic parameters for different characters in cabbage (pooled data)

Characters	Mean ± SE	Range	Genotype coefficient of correlation (GCV)	Phenotypic coefficient of correlation (PCV)	Heritability (h2)	Genetic advance (%age of mean)
Days to marketable Maturity	88.18±2.63	79.33 - 112.0	8.40	9.86	72.50	14.73
Gross weight/plant	1.01±0.04	0.59 - 2.03	30.33	31.36	93.50	60.33
Net weight of head/plant	0.59±0.04	0.33 - 1.09	26.34	29.22	62.30	9.31
Marketable heads (%)	87.13±2.23	70.67 - 94.33	5.73	7.26	62.30	9.31
Marketable head yield (q/ha)	251.96±17.95	126.83 - 364.00	24.33	27.28	79.50	44.64
Non-wrapper leaves/plant	13.24±0.71	10.33 - 17.50	7.90	12.27	41.10	10.49
Stalk length	10.87±0.80	6.50 - 17.83	15.91	20.45	60.60	25.47
Shape of head	0.95±0.02	0.73 - 1.25	14.06	14.74	94.50	28.33
Compactness of head	38.09±1.48	23.62 - 53.53	22.04	23.05	91.40	43.42
Harvest index	58.98±3.35	45.17 - 69.00	5.29	11.17	22.40	5.17

Table 3. Correlation coefficients among different characters in cabbage (pooled data)

Characters		Marketable head yield	1	2	3	4	5	6	7	8
Days to maturity	P	0.12								
	G	0.145								
Gross weight/plant	P	0.785**	0.129							
	G	0.865**	0.152							
Net wt. of head/plant	P	0.905**	0.084	0.891*						
	G	0.921**	0.087	0.925*						
Marketable head (%)	P	0.388	0.087	-0.029	0.0443					
	G	0.426*	0.095	-0.033	0.068					
Non-wrapper leaves/plant	P	0.404	0.327	0.750**	0.458*	-0.067				
	G	0.746**	0.549**	1.168	0.847**	-0.118				
Stalk length	P	0.019	-0.170	0.008	-0.034	0.141	0.128			
	G	-0.015	-0.223	-0.020	-0.082	0.206	0.314			
Shape of head	P	-0.390	-0.196	-0.458*	-0.484	0.124	-0.268	0.384		
	G	-0.451*	-0.239	-0.492*	-0.553**	0.175	-0.464*	0.511*		
Compactness of head	P	0.464*	0.376	0.157	0.232	0.491*	0.124	-0.179	0.000	
	G	0.553*	0.468*	0.170	0.277	0.632**	0.204	-0.215	-0.138	
Harvest index	P	0.111	-0.072	-0.314	0.092	0.051	-0.635**	-0.153	-0.138	0.086
	G	-0.239	-0.253	-0.561**	-0.358	0.050	-1.820	-0.410	-0.268	0.224

P and G: Phenotypic and Genotypic correlation coefficient, respectively
P*=0.05, **P=0.01

Table 4. Direct and indired contribution of different characters towards marketable head yield in cabbage (pooled data)

Characters	1	2	3	4	5	6	7	8	9	Genotypic correlation coefficient with Marketable head yieid
1. Days to maturity	-0.142	-0.135	0.126	0.013	0.045	-0.022	0.052	0.156	0.052	0.145
2. Gross weight /plant	-0.022	-0.888	1.407	-0.005	0.097	-0.002	0.107	0.057	0.115	0.865**
3. Net weight of head/plant	-0.012	-0.866	1.443	0.009	0.070	-0.008	0.120	0.092	0.073	0.921 **
4. Marketable head (%)	-0.013	0.029	0.098	0.139	-0.010	0.021	-0.038	0.210	-0.010	0.426*
5. Non-wrapper leaves/plant	-0.078	-1.038	1.223	-0.016	0.083	0.032	0.101	0.068	OJ 72	0.746**
6. Stalk length	0.032	0.018	-0.121	0.029	0.026	0.101	-0.111	-0.071	0.084	-0.015
7. Shape of head	0.034	0.437	-0.798	0.024	-0.038	0.051	-0.217	0.000	0.055	-0.451 *
8. Compactness of head	-0.066	-0.151	0.400	0.088	0.017	-0.022	0.000	OJ33	-0.046	0.553**
9. Harvest Index	0.036	0.4980	-0.516	0.007	-0.151	-0.041	0.58	0.74	-0.205	-0.239

Residual effect; 0.009. Underline figures indicate direct effects exhibit high heritability except for number of non-wrapper leaves and harvest index (Table 1). The highest genetic advance was predicted for gross weight (60.33) followed by net weight of head (48.65). These findings are in line with those of Jamwal *et al.* (1996). The gross weight and the net weight of head were found to highly variable and important character, which might be responsible for wide range in yield potential as listed in Table 2. These results are in agreement with Howe and Waters (1984) in cauliflower.

The estimate of correlation coefficients of economic traits with yield and among themselves provide the basis for identifying the traits for ideal type and indirect selection (Al-Jibouri, 1958). The genotypic correlation coefficients were higher in magnitude than the corresponding phenotypic ones, thereby suggesting strong inherent association between various characters studied (Table 3). These results corroborate the views of Thakur and Thakur (2002). At both genotypic and phenotypic levels, marketable yield was found to be positively and significantly associated with gross weight, net weight of head, number of non-wrapper leaves and compactness of head thereby indicating that these traits had certain inherent relationships with head yield. At genotypic level, the marketable head yield was found to be significantly and positively correlated with marketable head yield percentage (0.426). This suggested that improvement in these traits would result in increased marketable head yield. The present findings are in consonance with that of Jamwal et al. (1996) and Rai *et al.* (2003) who have also reported positive and significant association of head yield with gross weight, head net weight, marketable (%), non-wrapper leaves and compactness of head. The yield showed negative and should be based on smaller head shape index (flat to round). The yield components mostly exhibited significant interrelationship among themselves, which indicated the need of their simultaneous selection for improvement of desirable characters. Similar inter se associations of yield contributing traits in cabbage was also reported earlier (Gill *et al.*, 1977; Jamwal *et al.*, 1996; Rai *et al.*, 2003).

Knowledge of correlation alone, however, is often misleading as the correlation observed nay not be true. Two characters may show correlation just because they are correlated with a common third one. In such causes, it becomes necessary to study a method, which takes into account the casual relationship in addition to the degree of relationship. Path coefficient analysis is one such method that takes into account both kind of relationship. The data pertaining to path coefficient analysis (Table 4) revealed that net weight of head (1.443) had the highest direct effect on head yield followed by compactness of head (0.333), marketable head per cent (0.139), stalk length (0.101) and non-wrapper leaves (0.083). The gross weight and shape of head contributed indirectly towards head yield via net weight and gross weight, respectively. These results are in agreement with those reported by Sharma (1994), Jamwal *et al.* (1996) and Rai *et al.* (2003) in cabbage. The residual effect 0.009 revealed that all the characters under study contributed 99 percent of variation in yield. This indicated the adequacy of the characters while resorting to the selection in cabbage.

Thus, the present study suggests that net weight of head should be given utmost importance in selection programme aimed at breeding high yielding cabbage varieties. Due importance must also be given to compactness, marketable head (%), non-wrapper leaves and gross weight in the selection programme.

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THERMAL EFFICIENCY, GROWTH AND YIELD OF WHEAT

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ABSTRACT

The field experiment was conducted during two consecutive *rabi* seasons to find out the impact of thermal unit and its efficiency in growth and yield of wheat. The variety WH-711 was sown on two date of sowings (20th November and 20th December) under two planting systems (Flat bed and furrow irrigated raised bed planting system) and with three nitrogen levels (120 Kg N/ha, 150 Kg N/ha and 180 Kg N/ha). Wheat sown on 20th November consumed more thermal units than that of 20th December sown crop. The planting system also influenced the thermal unit requirement of wheat crop. The furrow irrigated raised bed planting system with two increased the thermal unit requirement over flat bed planting system. Nitrogen application also increased the efficiency of wheat crop in thermal unit consumption. Maximum value of thermal use efficiency increased from 0.7 to 0.8 (2002-03) and 0.6 to 0.8 g/m^2/cc day (2003-04) with increase in nitrogen application from 120 to 180 kg/ha. Highest thermal use efficiency was observed in wheat crop fertilized with 180 kg N/ha in both seasons. Thermal use efficiency explained the variability in leaf area index, dry matter and yield to the maximum extent.

Key words : Thermal units, thermal use efficiency, wheat, date of sowing, planting systems, nitrogen levels.

Wheat is one of most important dual purpose cereal crop which not only provide grains for human consumption but also straw yield for cattle wealth in the world. This crop had contributed immensely to the advent and florishment of green revolution in India, increasing production by six units in comparison to that of 1960's. Wheat is grown during the *rabi* season in India and is cultivated over an area of 25.92 million hectare with production of 71.81 million tones (Anonymous, 2004). The average productivity of wheat is 2770 kg per hectare in comparison with that of China and UK i.e., 8043 and 3885 kg per hectare, respectively (Anonymous, 2003). The low productivity of wheat in the country is mainly attributed to the delayed sowing, imbalanced and lower doses of fertilizer application, improper selection of varieties, poor irrigation facilities and adverse weather conditions. It depends largely on the prevailing weather conditions during crop growth period. A better understanding of weather resources can help in increasing the crop productivity (Kaur, *et al.*, 2004).

Temperature, humidity and radiation are major meteorological parameters which influence all aspects and stages of growth. Temperature is a key component of climate, determining the seedling unit and consequently the rate and duration of growth and productivity of the crop (Pal *et al.*, 2001). Temperature regulates many of the physical and chemical processes within the plant, which in turn control the rate of growth and development toward maturity. The crop growth and development depends upon the thermal unit or quantitative effect of temperature. High temperature strongly influence apparent photosynthesis and leaf area index of wheat in semi arid region (Johnson *et al.*, 1981). Agroclimatic indices are useful for assessing the agroclimatic resources in crop planning and reflecting the impact of agrometeorological variables at different crop growth stages. Thermal unit is a good estimator of wheat growth stages (Bauer *et al.*, 1985). However, soil moisture regime and fertilizer management can modify it considerably.

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Unit of sowing is also one of the most important factors which govern the crop phonological development and total biomass production along with efficient conversion of biomass into economic yield. Delayed sowing of wheat crop is exposed to sub optimal temperatures at establishment and supra optimal temperature at reproductive phase resulting into reduction of not only crop duration but also the yield (Sardana *et al.*, 1999).Keeping the above facts in view, the present study was undertaken to quantify the efficiency of thermal unit, growth and yield of wheat crop.

MATERIALS AND METHODS

A field experiment was conducted at the Department of Agronomy, C. Haryana Agricultural University, Hisar, which is situated at 29^0 10' N latitude, 75^0 46' E longitude and altitude of 215.2 meters above mean sea level during two consecutive rabi seasons of 2002-03 and 2003-04. The main plot treatment consisted of two dates of sowing (D$_1$-20th November and D$_2$-20 December) and two planting systems (P$_1$- Flat bed and P$_2$- furrow irrigated raised bed planting system) and three nitrogen levels (N$_1$- 120Kg N/ha, N$_2$- 150Kg N/ha and N$_3$- 180 Kg N/ ha) in sub plots. The twelve variety WH-711 was grown with all other recommended packages of practices by the University.

The observation on the days taken by various phonological events like crown root initiation, tillering, jointing, booting, anthesis, milking and physilolgical maturity were recorded from five tagged plants in each plot on alternate days daring the both crop seasons.

The plants from 25cm length were uprooted from each plot for leaf area measurement by detaching the leaf from each uprooted plant and then passing them through leaf area meter (Licor 3000) at different phenophases and leaf area index was calculated by the following formula:

Leaf area index (LAI)= Leaf are of the plants (cm^2)/land area covered by the plants (cm^2)

The plant samples taken for leaf area index at different phonological stages were also used for dry matter and dried in sun. Thereafter these samples were dried in oven at 65±5^{0}C temperature till constant weight was stained. The dried in samples were weighed on an electric balance. The dey matter was then converted to dry weight per square meter. Plant height was measured with the help of meter scale at the unit of harvest. The biological yield, yield attributes and grain yield were recorded at the unit of crop harvest.

The Agro-meteorological indices were computed using the daily meteorological data which was recorded at Agro-meteorological observatory situated near the experimental field.

Thermal Unit (TU)

Thermal unit between two phonological stages, a and b is defined as:

$$TU(^0Cday)=\sum_{a}^{b}[\frac{(T_{max}+T_{min}}{2}-T_{base}$$

where,

T_{max} = daily maximum temperature (^{0}C)

T_{min} = daily minimum temperature (^{0}C)

T_{base}= base temperature as 5^{0}C for wheat crop (Bishnoi *et al.*, 1995)

a = starting date of phenophase,

b = ending date of that phenophase.

Thermal use efficiency (TUE)

It is defined as the ratio of dry matter produced to the cumulative thermal units used during that period

Thermal use efficiency (TUE, g/m^2/^{0}C day)=

$$\frac{DM(g/m^2)}{\sum TU(^0Cday)}$$

where, DM is dry matter

The date on agro meteorological indices, growth and yield were statistically analyzed by the method of analysis of variance (ANOVA) as described by Panse and Sukhatme (1995.) The significance of treatment effects were computed with the help of 'F' (Variance ratio) test and to judge the significance of differences between treatments, critical difference (CD) was worked out as described by Gomez and Gomez (1984). The coefficient of correlation (r) and regression analysis were carried out to develop the relationship between agro meteorological and agronomic parameters.

RESULTS AND DISCUSSION

Energy indices such as thermal unit and thermal use efficiency were computed for all the treatment at various phenophases and were discussed in following heads:

Thermal Units

Thermal unit requirement for completion of different phonological stages of wheat under different treatments were worked out during 2002-03 and 2003-04 seasons and are presented in Table 1. The cumulative thermal unit requirement were significantly higher in 20th November sown crop as compared to 20th December sown crop at all the phonological stages. These values at physiological maturity were 1617.4 and 1498.9^{0}C day in D_1 and D_2 during crop season of 2002-03, respectively. The corresponding values for the second crop season were 1600.5 and 1452.2^0 C day, respectively. The wheat crop sown on 20th November consumed more thermal unit as compare to 20th December sown crop because early sown crop took more days to mature as compared to late sown wheat crop. Agarwal *et al.* (1999) also reported that as the planting was delayed lesser number of heat units were recorded from sowing to maturity in maturity in wheat.

The planting system also influenced the thermal unit requirement of wheat crop. The furrow irrigated raised bed planting system with two rows increased the thermal unit requirement over flat bed planting system with two rows increased the thermal unit requirement over flat bed planting system. This might be due to enhanced crop maturity in former as compared to latter planting system. This might be due to enhanced crop maturity in former as compared to latter planting system. The thermal unit requirement also varied with the nitrogen levels in wheat crop. Its values at physiological maturity were 1518.9, 1566.3 and 1590.8^0 C day in N_1 N_2 and N_3 levels of nitrogen during 2002-03, respectively. The corresponding values for the second season were 1480.8, 1537.2 and 1561.2^0 C day, respectively. The thermal unit requirement was maximum in N_3 due to enhanced crop maturity in N_3 over other lvels of nitrogen. Pal *et al.* (1996) also reported the similar finding. The first season of wheat showed higher thermal unit consumption for physiological maturity in all the treatments as compared to second season of wheat. This was due to comparatively higher temperature prevailed and days required for maturing by former crop then that of latter crop. Thermal unit can be used for describing the temperature response to growth and development of crop.

Thermal use efficiency

The variations in thermal use efficiency for biomass production of wheat crop among various phenophases and treatments during

Table 1. EEffect of different treatments on thermal units (^{0}C day) at various phenophases of wheat

Treatment	CR1		Tillering		Jointing		Booting		Anthesis	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
D_1	249.2	245.1	455.3	385.3	547.0	540.4	734.5	725.4	830.9	825.7
D_2	166.2	160.8	292.6	288.3	461.7	455.3	631.4	621.7	724.8	715.0
CD at 5%	5.6	11.3	2.6	3.5	3.6	7.1	5.5	5.8	4.9	9.1
P_1	202.4	193.5	369.2	334.0	497.0	490.1	672.9	657.6	762.5	755.2
P_2	212.9	212.3	378.7	339.6	511.7	505.7	693.0	689.6	793.2	785.5
CD at 5%	5.6	NS	2.6	3.5	3.6	7.1	5.5	5.8	4.9	9.1
N_1	207.7	202.9	361.1	331.0	490.0	482.6	659.4	654.2	754.0	744.1

Table 2. Effect of different treatments on thermal use efficiency (g/m^2/°C day) at various phenophases of wheat

Treat ment	CRI		Tillering		Jointing		Booting		Anthesis		Miliking		Maturity	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
D_1	0.02	0.02	0.09	0.08	0.27	0.23	0.54	0.49	0.77	0.72	0.75	0.70	0.67	0.62
D_2	0.02	0.02	0.08	0.08	0.22	0.20	0.44	0.40	0.70	0.68	0.68	0.64	0.62	0.60
P_1	0.03	0.02	0.09	0.09	0.27	0.23	0.53	0.47	0.78	0.74	0.75	0.70	.066	0.63
P_2	0.02	0.02	0.08	0.07	0.22	0.19	0.44	0.41	0.70	0.67	0.68	0.63	0.63	0.59
N_1	0.02	0.02	0.08	0.07	0.22	0.18	0.42	0.36	0.68	0.63	0.66	0.59	0.62	0.57
N_2	0.02	0.02	0.08	0.08	0.23	0.21	0.46	0.46	0.71	0.71	0.70	0.68	0.64	0.61
N_3	0.03	0.03	0.09	0.09	0.25	0.25	0.25	0.51	0.77	0.71	0.74	0.22	0.66	0.64

2002-03 and 2003-04 has been among various phenophases and treatments during 2002-03 and 2003-04 has been presented in Table 2. Thermal use efficiency showed and increasing trend with advancement of growth and attained maxima at anthesis stage. Further it declined with advancement in crop growth in all the treatments due to senescence of leaves. Thermal use efficiency was higher in first season as compared to second season in all the treatments. This was due to lower minimum temperature prevailed during 1st season. The reduction in thermal use efficiency due to delay in sowing were earlier reported by Kaur *et al.* (2004) and Pandey *et al.* (2004) in wheat crop.

The wheat crop sown first was more efficient in thermal unit consumption over late sown crop. This might be due to maximum thermal consumption and dry matter production in first sown crop. Among the planting systems, flat bed was more efficient in thermal unit consumption than furrow irrigated ridge bed system. This was because of higher thermal unit and dry matter production by former planting system as compared to latter planting system. Maximum value of thermal use efficiency increased from 0.7 to 0.8 (2002-03) and 0.6 to 0.8 g/m^2/^{0}C Day (2003-04) with increase in nitrogen application from 120 to 180 kg/ha. Highest thermal use efficiency was observed in wheat crop fertilized with 180 kg N/ha in both seasons. This might be due to maximum thermal unit and dry matter production in this nitrogen level. Relation between agronomic parameters and thermal indices

The date of all the treatments and both the seasons were pooled for correlation and regression analysis. The correlation coefficients of agronomic parameters (leaf area index, plant height, dry matter, yields, number of grains/ear and test weight) with thermal unit and thermal use efficiency at different phenophases are presented in Table 3. Both the energy indices were directly and significantly correlated with agronomical parameters. Except grains spike-1 and test weight, all the crop parameters were comparatively better correlated with thermal use efficiency as compared to thermal units,.

Table 3. Correlation of agronomical parameters with thermal use efficiency at various phenophases of wheat.

Parameters	TU_1	TU_2	TU_3	TU_4	TUE_1	TUE_2	TUE_3	TUE_4
Max. LAI	0.58	0.58	0.82	0.76	0.78	0.86	0.87	0.85
DM	0.78	0.54	0.85	0.84	0.73	0.56	0.92	0.93
Plant height	0.65	0.66	0.92	0.84	0.64	0.75	0.79	0.80
Yield	0.77	0.49	0.84	0.82	0.71	0.84	0.91	0.94
no of grins/ear	0.76	0.81	0.97	0.94	0.48	0.60	0.67	0.67
Test weight	0.62	0.70	0.91	0.85	0.54	0.67	0.71	0.71

1 Tillering 2 Anthesis 3 Milking 4 Physiological Maturity
Significant value of 'r' at $p < 2005 = \pm 0.53$

Simple regression equations were developed for the estimation of leaf area index. dry matter and yield using significant thermal indices. The thermal unit explained the variation in leaf area index dry matter and yield upto 58, 73 and 71 percent, respectively. Whereas thermal use efficiency improved the predictability of these equations i.e. 73 percent for leaf area index, 85 percent for dry matter and 88 percent for grain yield.

The wheat crop sown on 20th November used maximum thermal unit with its maximum efficiency. Flat bed sown system of wheat crop improved over furrow irrigated ridge bed planting system. Application of nitrogen had increased thermal consumption of wheat. Energy indices were directly related to growth and yield parameters and thermal use efficiency explained the maximum variability in crop parameters.

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NUTRIENT USE EFFICIENCY IN VEGETABLE PEA UNDER ORGANIC MODULE

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ABSTRACT

The present paper highlights the effect of organic module (combined application of pressmud with seed treatment of biofertilizer) on yield, nutrient use efficiency and economics of pea cultivation. A significantly higher nitrogen, phosphorus and sulphur content in soil and their uptake by grain was noted. The nutrient utilization use efficiency of 20.8 kg/kg N, 148 kg/kg P and 176.2 kg/ kg S more under press mud @ 5 t/ha with dual inoculation of biofertilizer compared to its conventional practices. The interaction impact on grain yield and interaction on economically nutrient use efficiency was respectively (18.6 to 62.7,00 to 27.3%) and higher benefit obtained (2.4 rupee/ rupee invested) was realized under pressmud @ 5t/ha with dual inoculation of biofertilizer.

Key words : Yield, nutrient use efficiency, C:B ratio, organic module, pea.

Due to intensive crop production and indiscriminate use of inorganic fertilizers, the agricultural lands worldwide have become vulnerable to degradative processes such as soil erosion, nutrient depletion and loss of organic matter and have suffered a consequent decline in soil productivity. There is a need to supplement the inorganic fertilizers through application of organic inputs and biofertilizers to the maximum possible low-level use of chemical fertilizer. The restoration and productivity of soil can be enhanced by using various off-from sources of organic wastes, including pressmud, biofertilizers, agricultural and industrial wastes.

The biofertilizers and organic source on economically viable, ecologically sound and attractive means of the reducing input of fertilizers particularly benefit the resource to the poor farmers. These technologies are not only the store house of a large number of essential nutrients but also improve physical environment of the soil. It is imperative to practice organic input system through combined use of biofertilizers and pressmud. In this context an experiment was conducted to study the effect of organic input on economic yield of vegetable pea.

MATERIALS AND METHODS

The present experiment was conducted during *rabi* season of 2002-03, 2003-04 and 2004-05 in a sandy loan alluvial soil, seeds of Arkel prominent Vegetable pea of eastern Uttar Pradesh were sown in field experiments.

Six treatment combinations were used in the experiments: T_1 - control, T_2- pressmud @ 5t/ha, T_3 - pressmud @ 5t/ha plus seed treatments in *Rhizobium* T_3, T_4 - pressmud @ 5t/ha plus seed treatments in PSB, T_5 - press mud @ 5t/ha plus seed treatments in *Rhizobium* with PSB, T_6 - conventional farmers technique (i) poor farmers use of without or less amount of fertilizer (ii) rich farmers use of recommended fertilizer. The design of experiment followed was split plot design. The basic properties of the soil were: pH 7.6,EC 0.41 dSm^{-1}, available N 270 kg ha^{-1}, P_2O_5 18 kg ha^{-1} and K_2O 180 kg ha^{-1}; sulphur 10 kg ha^{-1}, organic carbon 0.38% and (CA^{+2} + Mg^{+2}) 6.42 meq/100g soil and just before sowing. The biofertilizer for this experiment, the strain of nitrogen fixing bacteria and phosphate solubilization microorganisms were isolated from agronomic soil in IIVR Varanasi. The phosphorus solubilizers were cultured (PSB) and nitrogen fixer culture eg. *Phizobium leguminosarum*, seed inoculation alone or with dual inoculation

Rhizobium, and phosphate solubilizing bacteria seed treated with vegetable pea group Rhizobial inoculants and phosphate solubilizing bacteria seed treated with vegetale pea group Rhizobial inoculants and PSB before sowing as per the treatment. Culture slurry of biofertilizer @ 200 gm each 10 liters water at sowing as per the treatment. Culture slurry for 15 minute and thoroughly mixed to get uniform coating on all the seeds. Again the seeds were treated with PSB slurry in the same manner and dried for 15 minutes then the uniform coated seeds were dibbled in the field immediately. Required and measured quantity of seeds in plastic bucket (25 liter capacity) and recommended quantity of individual biofertilizers used for treatment. Yield, nutrient content and used efficiency, economics, etc were computed (Singh and Agarwal, 2005; Singh *et al.*, 2005).

RESULTS AND DISCUSSION

Grain yield

Treatments, T_4, T_2 and T_3 was registered 62.7%, 50.8% and 47.4%higher grain yield over control. Significantly higher yield and yield attributes were obtained under pressmud @ 5 t/ ha along with seed treatment with *Rhizobium* and PSB compared to single or un-inoculated crop. Inoculation with *Rhizobium* and PSB resulted in higher availability of N and P, which caused significant improvement in crop growth and net assimilation rate and leaf index (Table 2). The improvement was more conspicuous under dual inoculation because associative effect between *Rhizobium* and PSB inoculation resulted significantly the growth and yield attributes compared to single or un-inoculation (Singh and Singh 1992; Press *et al.*, 1989).

Solubilization of inorganic phosphorus in the rhizosphere soil was due to activity of PSB. PSB can promote plant growth by altering root growth and morphology of root, increase water and mineral nutrient absorptive capacity which may further stimulate higher yield (Downey and Kessel, 1990; Heisingr, 1998; Chamber, 1992). More pronounced effect of combined inoculation (*Rhizobium* and PSB) on yield attributes over single of uninoculation was also observed (Alagawadi and Gaur, 1988; Tyagi *et al.*, 2003; Tanwar *et al,*; Srivastava and Ahlawat 1995).

Nutrient content and uptake in grain

Significantly higher phosphorus, nitrogen and sulphur content and uptake in grain was found when the application of pressmud @ 5t ha^{-1} along with *Rhizobium* and PSB had lead to highest phosphorus percentage and uptake by grain (0.52,3.8 0.35 and 5.4,35.5,3.4 kg/ha), respectively followed by application of pressmud @ 5 t/ha along with individual *Rhizobium* or PSB. The inoculation of PSB was responsible for significant increase in P and nitrogen content and uptake by gain. Inoculation of *Rhizobium* produce favorable effect on availability of nitrogen in root zone was realized by fixing more atmospheric N by *Rhizobium* (Tanwar *et al.*, 2003; Srivastava and Ahlawat, 1995). PSB plays a vital role in the solubilization of various insoluble inorganic and organic phosphates present in soil or added phosphatic fertilizers. Production of organic acid by microorganism appears to be the major factor in solubilization of inorganic phosphate (Algawadi and Gaur, 1988; Kumawat and Khongarot, 2002; Tyagi *et al.*, 2003; Chaudhary *et al.*, 2003; Singh and Singh, 1992).

Nutrient use efficiency versus grain yield

Maximum utilization use efficiency of nitrogen, phosphorus and sulphur (20.8 kg/kg, 148 kg/kg and 176.2 kg/kg) respectively were seen when the application of Pressmud @ 5 t/ha with dual inoculation of biofertilizers (*Rhizobium* and PSB). This treatment also similarly shown the effect on interaction on grain yield increased from 2.92 to 27.3% of compared to conventional farmers technique (Table 1). Biofertilizers based on the release of enzymes, metabolites, growth promoters and as inducers of systemic disease resistance and promote nitrogen, phosphorus supply through increase nitrogenase activity by *Rhizobium* and produce humic substances and pressmud form stable complexes with phosphates which are readily absorbed by plants which results in higher utilization use efficiency versus grain yield (Dart, 1986; Jose Mariano *et al.*, 2001; Kevin Vessey, 200; Gull *et al.*, 2003 and Singh *et al.*, 2005).

Table 1. Effect of organic input on yield, nutrient content, uptake and use efficiency in vegetable pea

Treatment		Yield q/ha	Nutrient content in grain (%)			Nutrient uptake by grain (kg/kg)			Use efficiency of nutrient (kg/kg)		
			Nitrogen	Phosphorus	Sulphur	Nitrogen	Phosphorus	Sulphur	Nitrogen	Phosphorus	Sulphur
Control		5.9	3.0	0.42	0.17	17.7	2.5	1.3	-	-	-
Pressmud @ 5t/ha		7.9	3.5	0.51	0.35	26.6	4.0	2.6	20.1	133	153
Pressmud @ 5t/ha + *Rhizobium*		8.9	3.6	0.52	0.33	32.04	4.6	3.0	20.4	142.8	176
Pressmud @ 5t/ha + PSB		8.7	3.6	0.52	0.34	31.3	4.5	3.0	20.5	140	164.7
Pressmud @ 5t/ha + *Rhizobium* +PSB		9.6	3.8	0.52	0.35	35.5	5.0	3.4	20.8	148	176.2
Conventional farmer technique	Poor Farmer N_{30}Kg/ha	7.0	3.4	0.49	0.28	24	3.4	1.96	17.4	110	118.3
	Rich Farmer N_{30}, P_{60} kg/ha	8.2	3.5	0.50	0.33	28.7	4.1	2.7	20.4	143	164.3

Table 2. Effect of organic input on interaction effect on grain yield and economic values

Treatment	Interaction effect on economic use efficiency (%)	Cost of cultivation (Rs)	Gross return (Rs)	Net return (Rs)	Return per rupee invested	Interaction effect on grain yield
Control	-	11180	29500	18320	1.6	-
Pressmud @ 5t/ha	11.5	13620	39500	25880	1.9	33
Pressmud @ 5t/ha + *Rhizobium*	21.2	13820	44500	30680	2.1	50.8
Pressmud @ 5t/ha + PSB	18.9		43500	29620	2.1	47.5
Pressmud @ 5t/ha + *Rhizobium* + PSB	27.3	13970	47000	33300	2.4	62.7
Conventional farmer technique: Poor Farmer N_{30}Kg/ha	00	13248	35000	21752	1.6	18.6
Conventional farmer technique: Rich Farmer N_{30}, P_{60} kg/ha	10.6	14048	41000	26952	1.9	38.9

Interaction effect on grain yield

The result showed that increase in interaction impact on grain yield (18.6 to 62.7) variation when the application of pressmud @ 5t/ha with dual inoculation of biofertilizer compared to conventional farmers techniques.

Economic Value

The maximum net return of thirty four thousand two hundred nineteen nine rupee were obtained under application of pressmud @ 5 t/ha with dual inoculation of biofertilizers. The highest benefit cost ratio 1: 2.4 was recorded under this treatment.

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EFFECTIVITY OF *BRADYRIZOBIUM* IN BLACK GRAM (*VIGNA MUNGO*) UNDER FIELD CONDITIONS

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ABSTRACT

A field experiment consisting of five effective strains of *Bradyrhizobium* namely M-HP-1, 2, 3, 4 and 5 with two levels of nitrogen (20 and 40 kg N/ha) and absolute control was conducted in a northwest Himalayans acid alfisol soil using Black gram (*Vigna radiata*) for two successive *kharif* season of 2002 and 2003. Three indigenous strains of bradyrhizobium namely M-HP-1, M-HP-3 and M-HP-4 gave consistently better green pod yield, nitrogen content ad uptake than the control. Application of 40 kg N/ha, gave consistently better results than the incoculated strains.

Key words : Black gramm, bradyrhizobium, effectiveness, yield and nitrogen uptake

The most important dinitrogen fixation system in nature is the nodulated legumes with their specific and hightly efficient association with rhizobia. In agriculture, aout 80% of this biologically fixed is derived from symbiosis of involving legumes, which are grown species of *rhizobium* (Vance, 1998). Out of total N requirements, about 75-80% of the total N requirements of legumes can be met through symbiotic fixation (Verma, 1993).

Black gram (*Vigna radiata*) is the most important pulse crop of India as well as Himachal Pradesh. It is the rich source of protein and other nutrients. It occupies first place in *kharif* pulse both in Himachal Pradesh and other part of India. The productivity of pulses has declined after Green revolution. The main cause of productivity deterioration of pulses is imbalanced use of chemical fertilizers. Continuous imbalanced use and more and more application of nitrogenous fertilizers are affecting the soil bio- diversity, which causes susceptibility of diseases in pulse crops and to insect pests.

But if the N-requirement is met from fertilizer source alone then it suppresses appearance and functioning of nodules, apart from causing N pollution in soils and runoff water due to chemical fertilizers use (Pathak *et al.*, 1999). To obtain economically attractive and ecologically sound means to reduce the use of external inputs and improve the use of renewable source of energy, it becomes imperative to select the most efficient strain of *Bradyrhizobium* to get the maximum green pod yield of black gram crop. Keeping this in view, the present study was conducted to evaluate the efficient strain of *Bradyrhizobium* for better growth and yield of black gram cultivated in northwest Himalayan acid alfisol.

MATERIALS AND METHODS

The experiment was laid out in complete randomized block design with three replications. Black gram (cv-PDU-1) was sown in month of July for two consecutive years 2002 and 2003. Five authenticated efficient indigenous strains of *Bradyrhizobium* namely M-HP-1, M-HP-2, M-HP-3, M-HP-4 and M-HP5 were evaluated in comparison with two levels of nitrogen i.e. 20 and 40 kg/ha and control. Yield attributes i.e. nodule number, nodule dry weight, plant height, plant dry weight and root dry weight per plant was recorded at flowering stages during each year. Crop was harvested in the month of Oct during each year. Yield of the crop was recorded after harvest of the crop every year. Yield attributes and nitrogen content in different parts of plant were recorded at the flowering stage. Nitrogen content in grain and straw after the harvest of the crop were determined and data were presented on dry weight basis. Nitrogen in different parts of plant was determined by micro-kjeldhal method and nitrogen uptake by grain and straw were calculated. The recommended doses of phosphorus and nitrogen uptake by grain and straw were calculated. The recommended doses of phosphorus and potassium at the rate of 40 kg P_2O_5 an 20 kg K_2O/ha, were applied uniformly as basal dressing in all the treatments.

RESULTS AND DISCUSSION

Plant height: It is evident from Table 1 that the plant height did no differ singnificantly. The maximum plant height (13.8cm) was recorded in 40 kg N/ha applied treatment and minimum (11.2 cm) was recorded in control treatment. Plant heights in M-HP-4 and M-HP-5 inoculated strains were equal to the 40 kg N/ha applied treatment. Remaining treatments also registered higher plant height than the control treatment.

Shoot dry weight: shot dry wieght recorded at flowering stage presented in Table 1. It is discernible from the table that shoots weight differed significantly amongst different treatments. Forty kg N/ha applied treatment gave the highest (1.50g) and M-HP-2 gave the lowest (0.82g) shoot weight. Inoculation with *Bradyrhizobium* strains M-HP-4 and M-HP-5 registered the significantly higher shoot weight than the control. Rest of the strains were either numerically superior or inferior to the control. Application of starter dose nitrogen 20 kg N/ha gave statistically higher shoot dry weight than the control. *Bradyrhizonium* strain M-HP-5 registered numerically higher shoot weight than application of 20 kg N/ha.

Root dry weight: Root dry weight per plant at flowering stage differed significantly (Table 1.) The maximum (117.5 mg) and minimum (59.2 mg) were recorded in the 40 kg N ha^{-1} applied treatment and in strain M-HP-2 inoculated treatments, respectively. Control treatment registered significantly higher root weight than the strain M-HP-2. It may be noted that two strains, treatment M-HP-2 and strain M-HP-4 gave significantly lower root dry weights than control.

Nodule Number: Nodule number per plant differed singnificantly amongst different treatments. Strain M-HP-3 registered the higest (24.5) nodule number and application of 40 kg N ha-1 recorded the lowest (14.6) nodule number. The entire inoculated treatments gave the significantly higher nodule number than the control except the strain M-HP-4. Nodule numbers obtained in chemical fertilizer treatment were at par with all the rhizobium inoculated treatments except the strain M-HP-4. Application of higher doses of nitrogen (40 kg N ha^{-1}) significantly reduced the nodule numbers than other inoculated strains except the strain M-HP-4.

Nodule weight: Nodule weight per plant differed singnificantly under different treatments. The maximum (38.1 mg) nodule weight was recorded in treatment inoculated with strain M-HP-3 and minimum (17.1 mg) was recorded in the highest nitrogen (40 kg N/ha) applied treatment. Nodule weight obtanined in all the inoculated treatments was significantly higher than control and 40 kg N/ha applied treatments. It is known that the application of nitrogen through chemical fertilizers alone suppresses proper appearance and functioning of nodules. The results are supported with the findings of Pathak *et al.* (1999). Nodule weight obtained in 20 kg N/ha applied treatment was statistically superior to strain M-HP-1, M-HP-2 and control and 40 kg N/ha applied treatment. Nodule weight in all the inoculated strains differed significantly exept strains M-HP-1 and M-HP-2.

Grain yield: On the perusal of data from Table 1, it is clear that the grain yield obtained under different treatments differed significantly. The maximum (8.20q ha^{-1}) grain yield was obtained in 40 kg N/ha applied treatments and minimum (6.0 q ha^{-1}) in strain M-HP-2 inoculated treatment. Strain M-HP-3 and M-HP-4 recorded significantly higher yields than control and were at par with 40 kg N ha^{-1} applied treatment. It was reported that location specific indigenous strain performed better for yield and their attributes (Sharma *et al.* 2002). The rest of the treatments were statistically inferior than 40 kg N ha^{-1} applied treatments. The strain M-HP2 and M-HP-5 gave numerically less yield than the control.

Straw yield: It is clear that the straw yield differed significantly in different treatments (Table 1). But it did not follow a constant trend. The maximum (23.4 q ha^{-1}) straw yield was obtained in the 40 kg N ha^{-1} applied treatment and minimum (15.8q ha^{-1}) was recorded in the strain M-HP-2 inoculated treatment. Strain M-HP-1 and M-HP-3 recorded significantly at par straw yield to 40 kg N ha^{-1} applied treatments except 20 kg N applied treatment. The rest of the treatments were statistically inferior to 40 kg N ha^{-1} applied treatment.

Nodule nitrogen: Nodule nitrogen content differed significantly under treatments. The maximum (2.50%) nitrogen content was recorded in the 40 kg N ha^{-1} applied treatment and the minimum (2.14%) was recorded in strain M-HP-2 registered the highest (2.30%) nitrogen content and M-HP-4 registered the lowest (2.14%) nitrogen content. It might be due to the fact that nitrogen fixation occurs inside the nodule and the efficient strains do not retain nitrogen in the nodule but traslocat it to the root showing better symbiosis and the inefficient strain retained the nitrogen inside the nodule (Dubey *et al.*, 1992).

Shoot nitrogen: Nitrogen content in shoot differed significantly amongst different treatments. Under different inoculated treatments, strain M-HP-5 gave statistically higher nitrogen content than strain M-HP-2, and other strains were statistically at par with each others. The maximum (3.67%) nitrogen content was observed in the 40 kg N ha^{-1} applied treatment and the minimum (3.20%) was recorded in strain M-HP-2 inoculated treatment.

Root nitrogen: It is discernible from Table 2 that the nitrogen content in the roots differed significantly under different treatments. Under different inoculated treatments, it was maximum (2.65%) in strain M-HP-1 inoculated treatment and the minimum (2.35%) was recorded in strain M-HP-2 inoculated. The highest (2.70%) nitrogen content was observed in the 40 kg N/ ha^{-1} applied treatment. Application of starter dose of chemical nitrogen (20 kg N ha^{-1}) registered statistically at par with nitrogen content at 40 kg N ha^{-1} applied treatment and control treatment.

Grain nitrogen: Nitrogen content in grain deffered significantly under different treatments. Nitrogen content was the maximum (3.80%) in 40 kg N ha^{-1} applied treatment and the minimum (3.45%) was recorded in strain M-HP-2 inoculated. Application of lower dose of nitrogen (20kg N ha^{-1}) registered the higher nitrogen concentration than the inoculated treatments and control was statistically at par 40 kg ha^{-1} applied treatment.

Table 1. Effect of nitrogen and *Rhizobium* culture (*Bradyrhizobium*) inoculation on yield attributes and yield of black gram (Data pooled over two years)

Treatment	Plant height (cm)	Dry weight/ plant (g)	Root dry weight/ plant (mg)	Nodule number/ plant	Nodule dry weight/ plant (mg)	Grain yield (q/ha)	Straw yield (q/ha)
M-HP-1	12.8	0.85	87.5	19.8	23.9	7.3	21.8
M-HP-2	12.2	0.82	59.2	22.7	25.3	6.0	15.8
M-HP-3	13.3	0.90	89.5	24.5	38.1	7.2	19.9
M-HP-4	13.8	1.10	72.9	17.7	29.9	7.5	17.7
M-HP-5	13.8	1.40	81.4	21.2	34.1	6.1	17.9
N_{20} kg ha^{-1}	13.1	1.30	96.8	21.1	30.9	6.8	21.5
N_{40} kg ha^{-1}	13.8	1.50	117.5	14.6	17.3	8.2	23.4
Control	11.2	0.89	81.8	17.3	22.1	6.3	18.4
CD(P=0.05)	NS	0.12	5.40	3.46	2.60	1.20	3.72

Table 2. Effect of nitrogen and *Rhizobium* culture (*Bradyrhizobium*) inoculation on nitrogen concentration in nodule shoot and root at flowering stage in grain and straw of black gram (data pooted over two years.)

Treatment	%N in nodule	%N in root	%N in shoot	%N in grain	%N in straw
M-HP-1	2.21	2.65	3.40	3.70	2.48
M-HP-2	2.30	2.35	3.20	3.45	2.38
M-HP-3	2.20	2.40	3.32	3.56	2.34
M-HP-4	2.14	2.60	3.36	3.72	2.36
M-HP-5	2.17	2.55	3.45	3.67	2.42
N_{20} kg ha^{-1}	2.18	2.60	3.47	3.76	2.37
N_{40} kg ha^{-1}	2.50	2.70	3.67	3.80	2.47
Control	2.20	2.50	3.50	3.72	2.28
CD(P=0.05)	0.12	0.19	0.14	0.24	0.13

Straw nitrogen: Nitrogen in grain differed significantly under different treatments (Table 2). Under different inoculated treatments, it was the maximum (2.48%) in strain M -HP-1 inoculated trreatment and the minimin (2.34%) was recorded in strain M-HP-3 inoculated. In control, it was lowest (2.28%) and was statistically inferior to 40 kg N ha^{-1} applied treatment and strain M-HP-1 inoculated treatment. Straw nitrogen content observed in control treatment was statistically at par with rest of treatments. Positive response of Rhizobial inoculation resulted in better nodule formation as depicted from the nodule weight, and the nitrogen translocated to other plant parts resulted in higher green pod yield, nitrogen concentration and protein content. Similar results were obtained by McKenzie *et al.* (2001) on legume see (Pea) protein.

Nitrogen uptake: Nirogen content in the grain and straw was determined after the harvest of crop and presented on dry weight basis. Nitrogen uptake was calculated by multiplying nitrogen concentration with respective grain and straw yield on dry weight basis to get the nitrogen uptake by grain and straw individually and the sum of grain and straw provided the total uptake by grain and straw.

Uptake by grain: On the perusal of uptake data from Table 3, it is evident that nitrogen uptake by grain differed significantly under different treatments. Nitrogen uptake was the maximum (31.16 kg N) in 40 kg N ha^{-1} applied treatment (25.57 kg N), respectively. Strain M-HP-2 registered the lowest (20.70kg N) and significantly lower uptake of nitrogen than the control.

Uptake by straw: Nitrogen uptake by straw differed significantly amongst different treatments (Table 3). It was maximum under (54.06 kg N) in strain M-HP-1 inoculated treatment and the minimum (37.60 kg N) was recorded in strain M-HP-2 inoculated. All the inoculated treatments registered significantly higher nitrogen uptake than strain M-HP-2 except strain M-HP-4. Application of 40 kg N/ha gave the maximum (57.80 kg N) nitrogen uptake and the minimum (37.60 kg N) was recorded in strain M-HP-2 inoculated. Control treatment gave the numerically higher yield than Strain M-HP-2 and strain M-HP-4, respectively. This kind of trend may be due to ineffectiveness of strain or it might have not got the chance to express its full potenital. The results are corroborated with the finding of Pareek (1979) and Dubey *et al.* (2002).

Table 3. Effect of nitrogen and *Rhizobium* culture (*Bradyrhizobium*) inoculation on nitrogen uptake by grain, straw a nd total (grain + straw) of black gram (data pooled over two years)

Treatment	Nitrogen uptake by grain (kg N/ha)	Nitrogen uptake by straw (kg N/ha)	Total nitrogen uptake (grain + straw) (kg N/ha)
M-HP-1	26.01	54.06	80.7
M-HP-2	20.70	37.60	58.30
M-HP-3	25.63	45.57	72.20
M-HP-4	27.90	41.77	69.67
M-HP-5	22.39	43.32	65.71
N_{20} kg ha^{-1}	25.57	50.96	76.53
N_{40} kg ha^{-1}	31.16	57.80	88.96
Control	23.44	41.95	65.39
CD(P=0.05)	2.13	4.39	6.79

Total uptake: Differed significanlty amongst different treatments (Table 3). It was the maximum (88.96 kg N) in 40 kg N ha^{-1} applied treatment followed by strain M-HP-1 (79.85 kg N), 20 kg N ha^{-1} applied treatment (76.53 kg N) and strain M-HP-3 (72.20 Kg N), respectively (Table-3). Strain M-HP-2 registered the lowest (58.30 kg N) and gave significantly less uptake of nitrogen than the control. Total uptake by control was singnificantly inferior to strain M-HP-1 and strain M-HP-3. The rest of two strains i.e. strain M-HP-4 and strain M-HP-1 were statisticallyt at par with the control. The results are in conformity with finding those reported earlier on black gram crop by Begal and Jahav (1995).

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EFFECT OF LAND LAYOUTS AND NUTRIENT SOURCES ON QUALITY AND YIELD OF SWEET SORGHUM

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ABSTRACT

A field experiment constituting three land layouts, three nutrient sources and three interaction treatments was conducted in randomized block design (factorial) with three replications during *kharif* season of 2005, at Sorghum Research Station, M.A.U., Parbhani to study effect of land layouts and nutrient sources on quality and yield of sweet sorghum. The crop variety RSSV-9 was tried in this experiment. Among land layout treatments, the treatment L2-Sowing at 45 cm row spacing and opening furrow has recorded significantly higher juice yield 1/ha, test weight (g), bhoosa yield (kg/ha) and grain yield (kg/ha). In land layout treatments, results on mean brix per cent 90 DAS and at harvest, reducing sugar (%), non-reducing sugar (%) and ethanol yield (1/ha) were found non-significant. Among nutrient suources sources treatments treatment F_1 has recorded significantly more juice yield, mean brix a950 90 DAS, brix (%) at harvest, non-reducing sugar (%), ethanol yield (11ha), test weight (g), bhoosa yield and grain yield. While reducing sugar (%) was significantly more in treatment F_2: Juice quality characters were found non-significant in case of land layout treatments. The data on interaction (L x F) treatments was found non-significant in case of all characters under study.

Key words : Juice quality, sweet sorghum, land layout, nutrient sources.

Sweet sorghum holds a great potential as a field crop for ethanol production throughout the world, because it is adoptable for wide range of growing condition. It is cheaper than sugarcane requiring less field work, water and fertilizer being short in duration. The average yield of 37.7 metric tones of stalks and 2.2 metric tones of grain per ha of sweet sorghum were reported in Brazil under good management, utilizing both grain and stalk to produce alcohol. One hectare area can produce 3387 L/ha of ethanol in four months (Senaffert and Gourley, 1982). Sweet sorghums are identified as high energy sorghum (HES) due to high sugar content in stalk. Ethanol is a renewable source of energy which can be produced from feed stocks such as molasses, corn, sweet sorghum, etc. The use of ethanol for blending purposes is widely practiced around the world known as biofuel which is less polluting from CO_2, SO_2 and eco-friendly. To begin with the policy of blending of ethanol with petrol initially upto 5% and further 10% which in being sold in nine states. The performance of different sweet sorghum cultivars in Maharashtra showed wide range of stalk juice quality parameters such a brix (18.31-22.24%), sucrose (12.50-16.65%) and reducing sugars (0.73-1.99%). These values are quite comparable with those of sugarcane juice (Bapat *et al.*, 1983). It is therefore, possible and desirable to manufacture syrup, jiggery, sugar and thanol from the fresh stalk of sweet sorghum. This will improve the economic condition of sorghum growing farmers. So it is needed to maximize the green stalk yield as well as grain yield to extract more juice yield per hectare by utilizing the natural resources like rain water, the optimum requirements for land layouts and nutrient sources in different agro-climatic condition is yet not known for sweet sorghum.

So it was necessary to conduct experiment entitled with "Effect of land layouts and nutrient sources on quality and yield of sweet sorghum".

MATERIALS AND METHODS

The field experiment was conducted during *kharif* season of 2004 and was laid down in randomized block design (factorial) on the farm of Sorghum Research Station, Marathwada Agricultural University, Parbhani. The soil of experimental plot was well leveled and well drained with good water holding capacity. The pH of soil was 7.92. In this experiment there were 9 treatments, in which there were 3 treatments of land layouts L_1-flat bed, L_2-sowing at 45 cm row spacing and opening furrows, L3-paired planting at 30+60 cm and opening furrows, 3 treatments of nutrient sources, F_1-RDF (80:40:40 kg NPK/ha) F_2-FYM @ 5.0 t/ha, F_3-50% FYM + 50% RDF (2.5+FYM+40:20:20 kg NPK/ha) and 3 interaction treatments of land layouts and nutrient sources.

The variety tried in experiment was RSSV-9. Seeds were sown by dibbling method in the three land layouts 1) Flat bed 45 cm x 15 cm ii) sowing at 45 cm x 45 cm row spacing and iii) paired planting at 30 + 60 cm x 15 cm for getting 1.48 lakh plants per hectare as per treatments. The gross and net plot size was 4.5 m x 5.4 m and 3.6 m x 4.5 m, respectively. Furrows were opened with the help of Baliram plough in treatment L_2-(sowing at 45 cm row spacing and opening furrows) and L_3 (paired planting at 30 + 60 cm and opening furrows after 30 days) after sowing. The FYM was applied 15 days before commencement of rains as per treatments and mixed in soil. The basal application of fertilizer (half dose of nitrogen, full dose of P_2O_5 and K_2O) was done through Suphala to experimental units. Top dressing of remaining half dose of nitrogen was done 30 days after sowing through urea. In post gravest studies quantity of juice (1) was estimated on the basis of average juice quantity obtained after crushing of ten plants and total number of plants in net plot.

Brix percentage was recorded with hand refractometer at various growth stages of the crop. The reducing sugars and non-reducing sugars were estimated by Lane Eynon's Volumetric fehling solution method at harvest (A.O.A.C., 1980). The quantity of ethanol in the fermented juice at harvest was estimated by following the standard method (Thorat *et al.*, 1987). In yield observations, the weight of earhead (g) was recorded after complete during. The grain produce was air dried for two days and weight of grains was recorded. The bhoosa yield (kg) was recorded by substracting grain weight from earhead weight after threshing the earheads. The statistical analysis of the data was done by the standard statistical "analysis of variance". The null hypothesis was tested by 'F' test of significance to know whether observed treatment effects were real or not.

RESULTS AND DISCUSSION

The data on juice quality of sweet sorghum (Table 1) was not significantly influenced due to land layout treatments except juice yield. The data on juice yield (L/ha) was found significant in treatment L_2. Treatment L_2 recorded significantly higher juice yield (8456 1/ha) over L_1 (7787 L/ha) was at par with treatment L_3 (8038 L/ha). While the effect of plant layout treatments was found non-significant in other quality character.

Different nutrient sources have significantly influenced juice quality of sweet sorghum. As shown in Table 1. Significantly highest juice yield (L/ha) mean brix per cent at 90 DAS and at harvest, non-reducing sugar per cent and ethanol yield (L/ha) was recorded by treatment F_1 -RDF (80:40:40 kg NPK/ha). Treatment F_1 recorded, significantly highest juice yield -9059 L/ha which was more than any other treatment.

At 90 DAS treatment F_1-RDF 80:40:40 kg NPK/ha recorded highest brix value-145.14 percent which was significantly superior than treatment F_2-FYM application @ 5 t/ha (F_2) but was at par with treatment F_3 - 50% FYM + 50% RDF. At harvest treatment F_1 recorded significantly superior brix value 19.33 per cent over rest of nutrient sources. The data in Table 1 on reducing sugar (%) shows that the treatment F_2 recorded significantly highest reducing sugar 1.43 per cent but it was at par with treatment F_3, which has recorded reducing sugar 1.39 per cent. The data on non-reducing sugar (%) shows that the treatment F_1 recorded significantly highest non-reducing sugar 9.75 per cent over all other nutrient treatments. More nutrient supply

Table 1. Juice yield (L/ha), mean brix (%), reducing sugar (%), non-reducing sugar (%), ethanol yield (L/ha) of sweet sorghum as influenced by various treatments

Treatments	Juice Yield (L/ha)	Mean brix (%) 90 DAS	Mean brix (%) at harvest	Reducing sugar (%)	Non-reducing sugar (%)	Ethanol yield (L/ha)
Land layouts						
L_1- flat bed	7787	13.36	17.83	1.38	9.02	769
L_2-sowing at 45 cm row spacing and opening furrow	8456	14.33	18.27	1.39	9.03	796
L_3-paired planting at 30+60 cm and opening furrows	8038	13.31	17.61	1.38	9.72	777
SEm ±	174.53	0.50	0.31	0.05	0.14	10.18
CD at 5%	522.45	0.50	0.31	0.05	0.14	10.18
Nutrient sources						
F_1-RDF (80:40:40 NPK kg/ha)	9059	15.14	19.33	1.33	9.75	869
F_2-FYM @5 t/ha	7044	12.71	16.66	1.43	8.15	688
F_3-50% FYM+50% RDF	8178	13.75	17.72	1.39	8.87	784
SEm ±	174.53	0.50	0.31	0.01	0.14	11.89
CD at 58%	522.45	1.51	0.94	0.05	0.43	35.61
Interaction (LxF)						
SEm ±	302.30	0.87	0.54	0.03	0.25	20.60
CD at 5%	NS	NS	NS	NS	NS	NS
General mean	8094	13.87	17.90	1.38	8.92	781

through RDF increased biomass and green millable stalk, which increased non-reducing sugar (%) and mean brix values (%) at 90 DAS after sowing and at harvest. Similar results were recorded by Wanjari *et al.* (1996), Raut (2004) and Sinare (2005). Next best significant treatment was F_3 (50% FYM + 50% RDF) which has recorded non-reducing sugar 8.87 per cent. The perusal of data (Table 1) on ethanol yield shows that treatment F1 i.e. RDF 80:40:40 kg NPK/ha has produced highest ethanol yield 869 L/ha which was significantly higher over other two nutrient sources. Similar results were quoted by Coutinho *et al.* (1988). It was followed by treatment F_3-50% RDF (F_3) 784 L/ha and it was significantly higher over FYM application @ 5 t/ha (F_2) 688 L/ha.

The perusal of data (Table 1) shows that, the interaction effect of land layouts and nutrient sources (L x F) on juice yield, mean brix (%) at 90 DAS, and at harvest, reducing sugar (%), non-reducing sugar (%) and ethanol yield (L/ha) was found to be non-significant.

The data in Table 2 shows that different land layout treatments influenced 1000 grain weight (g), bhoosa yield (kg/ha) and grain yield (kg/ha) significantly. The treatment L_2-sowing at 45 cm row spacing and opening furrows was found significantly superior by recording 26.45 g test weight, but it was at par with treatment L_3 (25.62 g). The data on bhoosa yield (Table 2) shows that, the treatment L_2 (278 kg/ha) recorded significantly highest bhoosa yield over rest of the treatments. The later two treatments being at par with each other. The effect of land layouts on grain yield (kg/ha) was found to be significant. The treatment L_2 (sowing at 45 cm row spacing and opening furrow) recorded significantly more grain yield 661 kg/ha over rest of the land layouts. However, treatments L_3 and L_1 were found at par with each other. Moisture stress may led to less grain yield. Land layouts like sowing at 45 cm row spacing and opening furrow and paired planting at 30 + 60 cm and opening furrow helps to conserves moisture in

Table 2. 1000 grain weight (g), bhoosa yield (kg/ha) and mean grain yield (kg/ha) of sweet sorghum as influenced by various treatments

Treatments	1000 grain weight (%)	Bhoosa yield (kg/.ha)	Grain yield (kg/ha)
Land layouts			
L_1-flat bed	23.88	257	512
L_2-sowing at 45 cm row spacing and opening furrow	26.45	278	661
L_3-paired planting at 30+60 cm and opening furrows	25.62	261	522
SEm ±	0.57	1.51	13.24
CD at 5%	1.71	4.52	39.65
Nutrient sources			
F_1-RDF (80:40:40 NPK kg/ha)	26.73	272	627
F_2-FYM @5 t/ha	24.17	260	511
F_3-50% FYM+50% RDF	25.04	265	557
SEm ±	0.57	1.51	13.24
CD at 58%	1.71	4.52	39.65
Interaction (LxF)			
SEm ±	0.99	2.62	22.94
CD at 5%	NS	NS	NS
General mean	25.31	265	565

soil for good crop growth and more yield as compared to flat bed land layout. This helps to crop to get optimum water fro soil for more grain yield. These results are in agreement with Mastiholi (1994).

The perusal of data in Table 2 shows that, different nutrient sources have influenced test weight, bhoosa yield (kg/ha) significantly. The treatment F_1 (RDF) has recorded maximum test weight 25.04 g. The data regarding bhoosa yield was influenced significantly by different nutrient sources. Treatment F_2 recorded significantly more bhoosa yield 272 kg/ha over rest of the treatments. Next best significant treatment was F3, which has recorded grain yield 265 kg/ha. Perusal of data on grain yield in Table 2 shows that, treatment F_1 (RDF) has recorded significantly more grain yield 627 kg/ha over F_2 and F_3. The increase in bhoosa yield (kg/ha), grain yield (kg/ha) in treatment F1 may be due to more supply of readily available nutrients through RDF (80:40:40 kg NPK/ha). Grain yield get influenced more by supply of nutrients in different amounts and sources. Nutrients from FYM source are not readily available, because it required time to get decomposed and to release nutrients in available form. So; grain yield get increased significantly with increase in readily available nutrient supply. These results are in line with Patil *et al.* (1984), Balasubramanian and Ramamoorthy (1996).

The perusal of data (Table 2) shows that the interaction effect of land layouts and nutrient sources (L x F) on test weight, bhoosa yield and grain yield (kg/ha) was found to be non-significant. Interaction treatments could not reach upto significant level.

Among land layouts treatments, treatment L_2- sowing at 45 cm row spacing and opening furrows produced significantly higher juice yield (1/ha), 100 grain weight (g), bhoosa yield (kg/ha), grain yield (kg/ha). So, L_2 showed its superiority among land layo0ut treatments. Among nutrient source treatments, treatment F_1-80:40:40 NPK kg/ha recorded significantly higher juice yield (1/ha), mean brix (%) 90 DAS and at harvest non-reducing sugar (%), ethanol yield (L/ha), 1000 grain weight, bhoosa yield (kg/ha) and grain yield (kg/ha). So treatment F_2 showed its superiority among nutrient sources treatments. Results of interaction treatments could not reach upto significance level.

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VARIABILITY AND PATH ANALYSIS STUDIES IN WHEAT UNDER TEMPERATE CONDITIONS WITH REFERENCE TO KASHMIR

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Abstract

Twenty five accessions of wheat were evaluated at Regional Research Station, Wadure, Kashmir during *rabi* 2004 & 2005 for nine traits. Significant variation was recorded for awn length, spike length, plot yield, peduncle length and grain yield/spike. The magnitude of PCV was higher than GCV for all the traits studied. High to moderately high variability (GCV & PCV) coupled with high estimates of heritability was observed for peduncle length, spike length, number of grains/spike, grain yield/spike and awn length. High heritability coupled with high GA was observed for peduncle length, spike length, number of grains/spike, grain yield/spike and plot yield. The genotypic correlation coefficients were higher than showed positive correlation with grain yield/spike, number of grains/spike, awn length, number of spikelets/spike and plant height both at genotypic and phenotypic levels. Path analysis explained that plant height, grain yield/ spike, awn length and number of grains/spike exerted maximum positive direct effect on yield indicating their importance in determining the yield. It was concluded that grain yield/spike, number of grains/spike, awn length, number of spikelets/spike, plant height and peduncle length were the major contributing components to grain yield. Therefore, due emphasis should be given on these characters while selecting for high yield.

Key words : Wheat, variability, heritability, genetic advance, correlation, path coefficient.

Wheat is most important food crop of the country known for its adoption to wide range and to keep the food grain production parallel with growing population, there is urgent need to do continuous efforts for increasing the productivity of wheat through breeding. Yield being poly-genically controlled trait and is quantitatively inherited, any programme which aims at higher yields has to study the traits affecting it and the methods used in crop improvement programmes utilize the knowledge of genetic variability, heritability and it related components characters, which are of immense practical value for effective selection because they are based on genetic variances (Mahak *et al.*, 2002; Munawar *et al.*, 2003). Path coefficient analysis measures the direct influence of a variable upon others and permits the separation of correlation coefficients into components of direct and indirect effects on yield. Keeping the above into consideration present study was undertaken to analysis the nature and extent of variability and association of grain yield with other morpho-physiological traits under temperature conditions.

Materials and Methods

Twenty five diverse lines of wheat were evaluated in Randomized block design with three replications during *rabi* 2004 and *rabi* 2005 at Plant Breeding and Genetic Farm of Regional Research Station, SKUAST-K, Wadura, Sopore, Kashmir (37°17'N and 74°33'E at an altitude of 1524 m amsl) under temperate rainfed conditions. Each line was accommodated in three row of 3.0 m length with line-line spacing of 30 cm. Recommended package of practices were followed to raise a good crop. Observations were recorded on five randomly selected competitive plants in each plot for/ plant height (cm), peduncle length (cm), spike length (cm), number spikelets/spike, number of grains/spike, grain yield (g)/spike, 1000 seed weight (g), awn length (cm) and plot yield (g). Average values subjected to standard statistical procedures, namely, analysis of variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance. Phenotypic correlation coefficients and path analysis were done as described by Dewey & Lu (1959) to assess the associations, direct and indirect influence of various components on grain yield.

RESULTS AND DISCUSSION

Analysis of variance indicated significant differences among genotypes for all the characters studied. Estimates of coefficient of variability, heritability and genetic advance are presented in Table 1. A fairly good amount of variation was reflected by mean and range for most of the characters. High coefficient of variation was observed for awn length (20.49), spike length (14.45), plot yield (13.93), peduncle length (9.67) and grain yield/spike (9.69), which indicates high magnitude of variability in the experimental material. The phenotypic variances were higher than respective genotypic and environmental variances for all the characters studied. Similarly genotypic variances were higher than respective genotypic and environmental variances for all the characters indicating greater role of genotypic variance in phenotypic expression of character. A close resemblance between the corresponding estimates of PCV ad GCV suggests that the environment had little or no role in expression of different characters. Highest PCV and GCV were recorded for plot yield (29.50 & 26.01g), followed by peduncle length (28.88 & 27.21cm), awn length (28.31 & 19.53 cm), grain yield/spike (23.68 & 21.60g) and spike length (26.99 & 22.80 cm). The rest of the characters viz. plant height, number of spikelets/spike, number of grains/spike and 1000 seed weight exhibited low PCV and GCV values.

Estimates of heritability varied from 47.61 per cent for awn length to 98.22 per cent for number of grains/spike. By and large, all the characters, except awn length showed more than 70 per cent heritability. High variability (GCV & PCV) coupled with high estimates of heritability were observed for peduncle length, number of grains/spike, grain yield (g)/spike and awn length which indicates high advantage through selection. Though heritability is a good indication of genetic control in the expression of character, the heritability coupled with genetic advance can be of more use in predicting the effect of selecting such characters. The characters, namely, peduncle length, number of grains/spike and grain yield/spike exhibited comparatively higher estimates of GCV, heritability in broad sense and GA as percent of mean which is indicative of predominance of additive gene action in expression of such characters, therefore for such characters selection might be effective. Similar findings were reported by Sahu *et al.* (2005) and Mahantashivayogayya *et al.* (2003). The genetic advance (GA) gives an idea about the progress that can be achieved by selecting for the concerned trait. The GA as percent mean was maximum for peduncle length (52.82) followed by plot yield (47.24), number of grains/spike (42.99), grain yield (g)/spike (40.6) and spike length (39.68). The results are in accordance with earlier findings of Tiwari and Rawat 1993. High heritability estimates coupled with high GA were observed for peduncle length, spike length, number of grain/spike, grain yield/spike and plot yield. High heritability of these characters may be due to additive gene effects; hence these characters are likely to respond to direct selection. Similar results were reported by Sahu *et al.* (2005) and Khumkar *et al.* (2001).

Correlation and path coefficient analysis revealed that in general the genotypic correlation coefficients were higher in magnitude than phenotypic correlation coefficients showing the efficiency of genotypic estimates over phenotypic ones. This could be interpreted that although there was a strong inherent association between the characters studied, the phenotypic expression was lessened under the influence of environments. The grain yield/plot showed maximum magnitude of positive association (Table 2) with grain yield/spike (0.264 & 0.183) followed by number of grains/spike (0.236&0.061) and plant height (0.056 & 0.030) both at genotypic and phenotypic levels. These associations are important and are expected to

Table 1. Estimates of different genetic parameters for different characters in twenty five genotypes of wheat

Characters	MSS due to Genotypes	Range	Grand mean	CD (5%)	h2	CV	PCV	GCV	Variance components n2g	n2e	n2p	%GA
Plant height (cm)	252.76*	118.67-80.00	95.43	6.50	83.43	4.15	10.20	9.32	79.0	15.6	94.7	17.53
Peduncle length(cm)	89.53*	32.33-13.33	19.67	3.12	88.79	9.67	28.88	27.21	28.6	3.6	32.2	52.82
Spike length (cm)	7.89*	12.97-4.50	6.68	1.58	71.35	14.45	26.99	22.80	2.32	0.93	3.25	39.68
No.of spikelets/spike	4.90*	18.53-12.40	15.28	0.77	87.62	3.07	8.73	8.17	1.56	0.22	1.78	15.75
No. of grains/spike	119.7*	41.37-16.90	29.91	1.39	98.22	2.83	21.24	21.06	39.6	0.72	40.3	42.99
Grain yield/spike (g)	0.28*	1.89-0.89	1.36	0.22	83.24	9.69	23.68	21.60	0.08	0.02	0.10	40.60
1000 seed weight (cm)	48.89*	52.7-35.3	44.3	2.61	85.89	3.60	9.57	8.87	0.15	0.03	0.18	16.93
Awn length (cm)	5.36*	10.80-4.33	5.85	1.97	47.61	20.49	28.31	19.53	1.30	1.44	2.74	27.77
Plot yield (g)	37029.1*	574.33-141.33	408.09	93.27	77.72	13.93	29.50	26.01	11266	3229	14496	47.24

Table 2. Genotypic (upper diagonal) and phenotypic (lower diagonal) correlation coefficients for different pair of characters

Characters	Plant height (cm)	Peduncle length(cm)	Spike length (cm)	No. of spike-lets/spike	No. of grains spike	Grain yield /spike (g)	100 seed weight (g)	Awn length (cm)	Plot yield (g)
Plant height (cm)	0.000	0.784	0.071	0.071	-0.237	-0.197	0.476	-0.040	0.056
Peduncle length(cm)	0.676	0.000	0.130	-0.052	-0.078	0.120	0.244	0.064	-0.026
Spike length (cm)	0.056	0.106	0.000	0.426	0.320	0.317	0.279	0.978	-0.053
No.of spikelets/spike	0.062	-0.072	0.365	0.000	0.639	0.402	0.040	0.574	0.135
No. of grains/spike	-0.212	-0.068	0.267	0.581	0.000	0.741	-0.142	0.680	0.236
Grain yield/spike (g)	-0.146	0.103	0.245	0.352	0.687	0.000	0.022	0.690	0.264
1000 seed weight (cm)	0.400	0.233	0.225	0.035	-0.133	-0.002	0.000	0.073	-0.098
Awn length (cm)	-0.013	0.075	0.526	0.339	0.471	0.498	0.023	0.000	0.165
Plot yield (g)	0.030	-0.006	-0.067	0.061	0.202	0.183	-0.104	0.073	0.000

Table 3. Genotypic and phenotypic path coefficient analysis based on correlation

Characters	Plant height (cm)	Peduncle length (cm)	Spike length (cm)	No. of spike-lets/ Spike	No. of grains /spike	Grain yield /spike (g)	100 seed weight (cm)	Awn length (cm)	Correlation with yield (g)
Plant height	1.0239	-0.6392	-0.0101	-0.0170	-0.0068	-0.1196	-0.1699	-0.0051	0.056
(cm)	0.2622	-0.1047	-0.0055	-0.0065	-0.0455	-0.0219	-0.0478	-0.0000	0.030
Peduncle	0.8028	-0.8152	-0.0184	0.0125	-0.0022	0.0732	-0.0871	0.0080	-0.026
length(cm)	0.1775	-0.1547	-0.0102	0.0076	-0.0147	0.0154	-0.0279	0.0002	-0.006
Spike length	0.0728	-0.1060	-0.1418	-0.1018	0.0091	0.1928	-0.0996	0.1213	-0.053
(cm)	0.0149	-0.0165	-0.0962	-0.0382	0.0571	0.0366	-0.0269	0.0014	-0.067
No.of spikelets	0.0728	0.0427	-0.0604	-0.2389	0.0182	0.2442	-0.0146	0.0712	0.135
/spike	0.0164	0.0113	-0.0352	-0.1043	0.1243	0.0526	-0.0042	0.0009	0.061
No. of grains	-0.2433	0.0643	-0.0455	-0.1528	0.0285	0.4497	0.0508	0.0844	0.236
/ spike	-0.0558	0.0106	-0.0257	0.0607	0.2137	0.1027	0.0160	0.0013	0.202
Grain yield	-0.2018	-0.0983	-0.0451	-0.0961	0.0211	0.6068	-0.0082	0.0855	0.264
/spike (g)	-0.0385	-0.0160	-0.0236	-0.0367	0.1470	0.1493	0.0003	0.0014	0.183
1000 seed	0.4875	-0.1989	-0.0396	-0.0097	-0.0041	0.0139	-0.3568	0.0091	-0.09
weight (g)	0.1050	-0.0362	-0.0217	-0.0037	-0.0286	-0.0004	-0.1194	0.0000	-0.10
Awn length	-0.0418	-0.0528	-0.1388	-0.1373	0.0194	0.4187	-0.0263	0.1240	0.165
(cm)	-0.0036	-0.0117	-0.0506	-0.0354	0.1007	0.0744	-0.028	0.0027	0.0165

improve grain yield following improvement in either or jointly with these characters. Negative correlation of grain yield/plot was observed for peduncle length (-0.026 & -0.006), spike length (-0.053 & -0.067) and 1000 seed weight (-0098 & (-0.014). Peduncle length, spike length and 1000 seed weight showed strong positive interaction with plant height but they were negatively correlated with plot yield. So it could be interpreted that the characters showing significant positive association with grain yield/plot should be given preference during breeding to reduce the grain yield losses. Similar results were presented by Jaglan *et al.* (1997), Kler *et al.* (2003) and Satish *et al.* (2004). Positive correlation of a particular character with yield does not necessarily mean a direct, positive effect of that trait on yield. Therefore, the analysis of path coefficient analysis the cause and effect relationships and partitions the correlation into direct and indirect effects (Table 3). Maximum amount of positive direct effect on yield was exerted by plant height (1.0239), followed by grain yield/spike (0.6068), awn length (0.1240) and number of grains/spike (0.0285) indicating the importance of these traits in determining the yield. Therefore, these characters should be kept in mind while practicing selection aimed at the improvement of grain yield. Spikelets/spike had an influence on grain yield through positive indirect effect of grain yield/spike (0.24), whereas, number of grains/spike through grain yield/spike (0.44), awn length through grain yield/spike (0.41). On the other hand, direct effects of peduncle length, spike length, spikelets/spike, 1000 seed weight were negative. However, path analysis strongly pointed out the role of plant height, grain yield/spike and awn length in determination of grain yield, as the magnitude of their direct effects was largest. More weightage should be given to these traits, while exercising selection process. These results are in agreement with earlier findings of Nayeem and Baig (2003), Vikram *et al.* (2003).

Based on all the results it was interpreted that grain yield/spike, number of grains/spike, awn length, number of spikelets/spike and plant height were the major contributing components to grain yield. Therefore, due emphasis should be given to these characters while selecting for high grain yield in order to improve yield and productivity.

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INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND ECONOMICS OF RICE-SUNFLOWER CROPPING SYSTEM

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ABSTRACT

A field experiment was conducted during 2001 and 2002 at Agricultural College Farm, Rajendranagar, Hyderabad to study the conjunctive use of organic and inorganic nutrient sources on rice- sunflower cropping system. The seed and straw yield of rice with 25% recommended N substitution with organic source of nutrients was either significantly improved (FYM) or on par with complete inorganic fertilization, The residual effect of organic nutrients to preceding rice on seed yield of succeeding sunflower was also prominent. Graded levels of RDF to sunflower resulted in significantly higher yield of sunflower due to 100% RDF. The net returns and returns per rupee investment were also more with integrated nutrient management.

Key words : INM, rice-sunflower cropping system, yield, economics.

Agriculture continues to be the backbone of Indian economy. Acute shortage of food to feed the teeming million mouths in the post independent era compelled the exploitation resources. Soil and water have been exploited indiscriminately with less attention to restore soil fertility and ground water potential, Integrated nutrient management is one solution to mitigate this problem. Rice-rice is the predominant cropping system in areas where water is available plenty. Now a days the successful introduction of sunflower is widely gaining importance as a sequence crop after kharif rice owing to the low cost of cultivation and low water requirement with just 3-4 irrigations and still gaining dependable profits (Sharanappa and Shivaraj, 1993). It is well established fact that, the nutrients applied to one crop in the rotation, has a marked effect on the succeeding crop, both in terms of growth and yield. The effect is more pronounced when organic manures are used in preceding crop and the system productivity becomes sustainable through the integrated use of organic and inorganic sources (Hegde, 1998). Hence, the present experiment integrated nutrient management in rice-sunflower cropping system was conducted to test its sustainability and profitability.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* and seasons of 2001-02, 2002-03 on sandy loam soil at Agricultural College Farm, Rajendranagar, Hyderabad under irrigated conditions. The experiment was conducted in different fields during both years. The soil had a pH of 7.3 and 7.2 and electrical conductivity of 0.24 and 0.30 dSm^{-1} respectively during both the years. The soil available nitrogen was low (215, 210 kg ha^{-1}) while available phosphorus (26 an 24 kg ha^{-1}) and potassium (265 and 260 kg ha^{-1}) were medium. Rice was grown with eight treatments and three replications in randomized block design. They included no nitrogen, 75% and recommended level o N @ 120 kg ha^{-1} through fertilizer, 75 % N through fertilizer and 25 % N through the different organic Sources viz, FYM, vermicompost, glyricidie or sunnhemp, 75% RDFN+ 1% polyfeed spray (19:19:19% NPK) at panicle initiation, heading and flowering. All the organic sources were applied 10 days before transplanting of rice. Full dose of P (60 kg P_2O_5) and K (40 kg K_2O) along with 1/3rd of nitrogen applied basal to the crop. Remaining N was applied equally at maximum tailoring an panicle initiation stage. Rice variety Tellahamsa was transplanted on 10 and 16 July respectively, during 2001 and 2002 with a spacing of 20x10 cm. The plot size was 22x4m for rice crop. The sequence crop of sunflower was grown with four treatments as sub plots in every treatment of previously grown was grown rice crop considered as main plots in split plot lay out. The plot size was 5.5x4m. The crop was grown with spacing of 45x30 cm. The treatments included recommended level of 80-50-30 kg N, P_2O_5, K_2O ha^{-1} 75 and 50% recommended level and no fertilizers. The rainfall during the growth period of rice was 640.3mm in 2001 and 494.4 mm in 2002. The crop lodged at maturity during both the years. It was severe during the first year due to high rainfall intensity of 94.4 and 136.6 mm in two weeks at grain maturity, Similarly rainfall of 84 and 74.8 mm during two weeks at maturity was also harmful during the second year. Net returns were calculated by deducting cost of cultivation from gross returns. Returns per rupee investment was calculated by dividing the net returns with cost of cultivation.

RESULTS AND DISCUSSION

Yield

The integrated nutrient supply system sustained the productivity of rice sunflower cropping system. Rice fertilized with recommended level of 120 kg N ha^{-1} produced 3318 and 4595 kg ha^{-1} grain yields in 2001 and 2002 (Table 1). This was significantly more compared to the effect of 90 kg ha^{-1} in the second year. The integrated nutrient supply substituting 25% N through organic sources viz. FYM, vermicompost, glyricidia or sunnhemp increased the production significantly compared to the yield realized by the application of nitrogen entirely through the inorganic fertilizer in the first year. This difference was largely due to the loss of grain through severe lodging of the crop fertilized with nitrogen. In the second year, 25% substitution of nitrogenous fertilizer through vermicompost, glyricidia or sunnhemp the productivity on par with the effect of inorganic fertilization. How ever, the conjunctive use of FYM along with 75% recommended N through fertilizer enabled the crop to produce significantly more yield of rice through the conjunctive use of 25% substitution of N fertilizer with FYM, vermicompost, glyricidia or sunnhemp. The mean grain yield was 4367,4291, 4183, and 4390 kg ha^{-1} compared to 3957kg ha^{-1} obtained by the complete inorganic fertilization. The increased yield due to integration of organic and inorganic sources might be due to improvement in soil physical properties, better availability of nutrients for longer time through out the crop growth period. Significantly large quantity of rice straw was harvested by integrating 25 kg N with FYM during both the years. The other organic sources produced similar effect as that inorganic fertilization in the second year. The usefulness of integrated nitrogen supply to rice to increase yield compared to entire recommended nitrogen supplied through fertilizer was also repoted by several works (Aladakatti *et al.*,1996; Mahavishnan, 2001, Pradad, 2000).

Sunflower grown after rice which was not nourished with nitrogenous fertilizer produced low seed yield of 637 and 697 kg ha^{-1} in 2001-02 and 2002-03 (Table 2). The yield increased to 838 and 811 kg in 2001-02 and 826 kg in 2002 03 with 75% and recommended level of fertilization to rice. The improvement might be due to the increased mineralization of nutrients in the flooded rice soil, which were better utilized by sunflower. In the control plots available nutrients might be utilized from the pool of soil by rice crop in the absence o fertilization application. Hence, the sunflower yield was low. The residual effects of organic nutrients substituting 25%N fertilizer through FYM, vermicompost, glyricidia enabled the crop to produce significantly more seed and stalk yield during both the years. The mean yield of 2 years data also confirms the superiority of integration of organic and inorganic sources. The yield advantage probably appears to be due to the mineralized macro nutrients in addition to the microbial and physical improvement of the soil slowly and steadily over a period of time, which benefited the sunflower crop. (Sujathamma, 2000).

Sunflower fertilized with the recommended level of 80-50-30 kg NPK ha^{-1} produced 1060, 11 11 kg ha^{-1} seed yield 2001-02 and 2002-03. The yield is reduced significantly by reducing the

Table 1. Yield and economics of rice as influenced by integrated nutrient management

Treatments	Grain yield (kg/ha)			Straw yield (Kg/ha)			Net returns (Rs/ha)			Returns per rupee investment.		
	2001	2002	Mean	2001	2002	Mean	2001	2002	mean	2001	2002	mean
No nitrogen	2543	3232	2887	3128	3878	3503	4756	8950	6853	0.42	0.80	0.61
75% Recommended fertilizer N	3258	3939	3598	4138	4766	4452	8397	12433	10415	0.69	1.03	0.86
Recommended fertilizer N (FN)	3318	4595	3957	4347	5585	4966	8600	16225	12413	0.69	1.31	1.00
75%FN+25%N FYM	3784	4949	4367	4882	6005	5444	11077	18022	14550	0.87	1.41	2.28
75%FN+25%N vermicompost	3784	4797	4291	4898	5826	5362	8742	14735	11739	0.57	0.97	0.77
75%FN+25% N glyricidia	3821	4545	4183	4929	5545	5237	11735	15972	13854	0.95	1.29	1.12
75%FN+25%N sunnhemp	4033	4747	4390	5081	5755	5418	12827	17072	14950	1.03	1.37	1.20
75%FN+1% polyfeed spray at panicle initiation, Heading, and flowering	4148	4040	4094	5019	4888	4954	12236	11565	11901	0.90	0.85	0.87
CD at 5%	266	287	196	289	308	-	-	-	-	-	-	-

Table 2. Residual and direct effect of treatments on yield and economics of sunflower

Treatments	Seed yield (kg/ha)			Stalk yield (kg/ha)			Net returns (Rs/ha)			Returns per rupee investment		
	2001 -02	2002 -03	mean	2001 -02	2002 -03	mean	2001 -02	2002 -03	mean	2001 -02	2002 -03	mean
No nitrogen	637	697	667	1570	1684	1627	394	991	693	0.06	0.16	0.11
75% Recommended fertilizer N	838	831	835	1929	1958	1944	2404	2000	2202	0.38	0.31	0.34
Recommended fertilizer N (FN)	811	826	819	1868	1943	1905	2134	2276	2205	0.34	0.36	0.35
75%FN+25%N FYM	908	939	924	2027	2079	2053	3096	3414	3255	0.48	0.54	0.51
75%FN+25% N vermicompost	917	911	913	2048	2105	2077	3156	3126	3141	0.51	0.50	0.50
75%FN+25% N glyricidia	886	899	893	2028	2086	2057	2879	3011	2945	0.46	0.48	0.47
75%FN+25% N sunnhemp	874	867	871	2008	2001	2005	2761	2686	2724	0.43	0.43	0.43
75%FN+1%polyfeed spray at panicle initiation heading, and flowering	766	830	798	1791	1961	1876	1679	2321	2000	0.26	0.36	0.28
SE+	22	27	-	48	52	-	-	-	-	-	-	
CD at 5%	48	58	-	103	112	-	-	-	-	-	-	
Direct effect												
No fertilizers	561	585	858	1391	1470	1430	858	1095	977	0.18	0.23	0.20
50% recommended NPK	779	840	1902	1910	2025	1968	1902	2348	2125	0.31	0.40	0.35
75% recommended NPK	918	865	2790	2084	2055	2070	2790	2261	2526	0.44	0.35	0.39
Recommended NPK	1060	1111	3700	2248	2359	2304	3700	4209	3955	0.53	0.61	0.57
CD at 5%	4	10	-	20	18	_	-	-	-	-	-	-

fertilizer levels to 75 or 50% or no fertilizers. Stalk yield also followed similar trend.

Economics

The integrated supply systems were more expensive than the inorganic fertilization. Mean net returns of rice was Rs 12413 with application of recommended 120 kg N ha^{-1} through fertilizer (Table 1). Returns increased with application of 25% N through FYM, glyricidia, and sunhemp along with 75% N through chemical fertilizer. The returns per rupee investment were also higher with integrated nutrient management. Vermicompost though increased the yield, the net returns were low due to high cost involved in purchasing it. If the farmer owns vermicompost unit this is also a best option.

In sunflower also the residual effect of nutrient substitution to rice was prominent. The net returns were Rs. 3255, 3141, 2945 and 2724 with FYM, vermicompost, glyricidia and sunnhemp for 25% N substitution to rice, where as with complete inorganic fertilization it is Rs 2205 only. The returns per rupee invested were 0.51, 0.50, 0.47, 0.43 with FYM, vermicompost, glyricidia, and sunnhemp (Table 2).

In the direct effect of fertilizers on sunflower the net returns were increased with increase in level of fertilization Maximum net returns of Rs 3955 were obtained with recommended level of 80-50-30 Kg NPK ha^{-1}.

It can be concluded from the above experiment that substitution of 25% N to rice with organic sources viz FYM, vermicopost, glyricidia, or sunnhemp not only improves productivity but also sustain it. It also has significant residual effect on succeeding sunflower crop. The net returns were also more with integrated nutrient management.

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EFECT OF SEED PRIMING WITH K_2SO_4 ON GERMINATION AND SEEDLING GROWTH IN MAIZE

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ABSTRACT

Seeds of four maize genotypes (4212, 32A09, K-26 and G-2) were primed with K_2SO_4 salt at six concentrations (0.5%, 1.0%, 2.0%, 4.0%, 8.0% and 16.0%) for three durations (5 min, 30 min and 24h). Data were recorded after one week of sowing on root length, no. of roots/seedling, shoot length, no. of leaves/seedling, fresh and dry weights of seedling, along with percent germination. Seed priming with K_2SO_4 for 5 min and 30 min durations did not show any effect in maize, while treatment for 24h was effective in enhancing germination and seedling growth. Differential response of maize genotypes to seed priming with K_2SO_4 was observed with genotypes '4212' being highly responsive to K_2SO_4 salt particularly at 2.0% concentration compared to others.

Key words : Seed priming, maize, K_2SO_4 salt, seedling parameters.

Seed priming has been reported to improve the speed of germination (Tesfaye, 1992), seedling emergence (Tarquis and Bradford, 1992, Sung and Chang, 1993), time to reach 50% of final germination (Ellis and Butcher,1988) and field performance (Argerich and Bradford, 1989; Bradford *et al*., 1990). Therefore, an investigation was carried out to study the effect of seed priming with K_2SO_4 on germination and seedling growth in maize.

MATERIALS AND METHODS

Seeds of four maize genotypes *viz*. 4212, 32A09, K-26 and G-2 were given pre-sowing treatments (seed priming) with K_2SO_4 at six different concentrations (0.5%, 1.0%, 2.0%, 4.0%, 8.0% and 16.0%) for three different durations of 5 min, 30 min and 24h at room temperature. After the treatments, the seeds were air dried in shade for 24h, and then planted in seed beds in rows at a distance of 1 0 cm., during month of July in the year of 2004. Two sets of controls - one set pre-soaked only in water (hydro-priming) for the same duration as the treated, and another set without any pre-soaking in water or K_2SO_4 treatments - were used for all the 4 genotypes of maize. Data were recorded after one week of sowing on germination and also on various seedling parameters like on shoot length, no. of leaves/seedling, root length, no. of roots/seedling and seedling fresh and dry weights on 5 randomly selected seedling/treatments. For taking dry weight, the seedlings were dried in an oven at 60°C for 48h. The data were subjected to statistical analysis by following standard procedures. Fisher's t-test was applied to check the significance of the difference between treatments and respective control for a particular character.

RESULTS AND DISCUSSION

No effect was observed with K_2SO_4 treatment for very short periods of 5 min and 30 min. Hence, the data for these two durations are not shown here. The results on the effect of seed priming with K_2SO_4 for 24h on seed germination and various seedling parameters are presented in Table 1, 2 and 3. Seed priming (whether hydro-priming or treatments with potassium salt), in general, caused a marked improvement in seed germination (Table 1). However, the improvement in germination and seedling growth was better with seed priming with K_2SO_4 compared to hydro-priming. Maximum effect of seed priming with K_2SO_4 on germination was noticed in the genotype '4212' at 1.0% and 2.0%

Table 1. Effect of K_2SO_4 treatemetns for 24 h on germination and seedling fresh and dry weights in four maize genotypes.

Treatment (Seed priming)		Maize genotypes				Maize genotypes				Maize genotypes			
		4212	32A09	k-26	G-2	4212	32A09	k-26	G-2	4212	32A09	k-26	G-2
		Germination (%)				Seedling fresh weight (mg)				Seedling dry weight (mg)			
Control		53.5	86.6	86.6	72.6	876	1186	1116	1102	230	240	228	220
(No pre-soaking)		(100.00)*	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
Pre-soaking in water		66.6	93.3	93.3	79.2	884	1230	1368	1112	232	250	276	224
(Hydro-priming)		(124.48)	(107.74)	(107.74)	(100.9)	(100.91)	(103.70)	(122.58)	(100.90)	(100.86)	(104.16)	(121.05)	(101.82)
K_2SO_4	0.5%	66.6	93.3	100	93.3	1176	1436	1690	1202	268	344	298	276
		(124.48)	(107.74	(115.47)	(128.51)	(134.24)	(121.07)	(151.43)	(109.07)	(116.52)	(143.33)	(130.70)	(125.45)
"	1.0%	79.2	100	100	93.3	1228	1506	1488	1360	274	364	280	298
		(148.03)	(115.47)	(115.47)	(128.51)	(140.18)	(126.98)	(133.33)	(123.41)	(119.13)	(151.66)	(122.80)	(135.45)
"	2.0%	79.2	100	86.6	86.6	1488	1774	1460	1458	283	390	268	308
		(148.03)	(115.47)	(100.00)	(119.28)	(169.86)	(149.57)	(130.82)	(132.30)	(123.47)	(162.50)	(117.54)	(140.00)
"	4.0%	66.6	93.3	93.3	86.6	1296	1390	1438	1420	260	356	260	302
		(124.48)	(107.74)	(107.74)	(119.28)	(147.94)	(117.20)	(128.85)	(128.85)	(113.04)	(148.33)	(114.03)	(137.27)
"	8.0%	53.3	86.6	86.6	86.6	1084	1336	1368	1338	258	278	248	280
		(99.62)	(100.00)	(100.00)	(119.28)	(123.740	(112.64)	(122.58)	(121.41)	(112.17)	(115.83)	(108.77)	(127.27)
"	16.0%	53.3	86.6	93.3	66.6	906	1186	1288	1278	228	224	236	278
		(99.62)	(100.00)	(107.74)	(91.73)	(103.42)	(100.00)	(115.41)	(115.97)	(99.13)	(93.33)	(103.5)	(126.36)

* figures in parentheses indicate percetn control values.

Table 2. Effect of K_2SO_4 treatments for 24 h on seedling traits in 4 maize genotypes

Treatment (Seed priming)	No. roots/seedling				No. roots/seedling			
	4212	32A09	k-26	G-2	4212	32A09	k-26	G-2
Control (No pre-Soaking)	3.80±0.18 (3-4)#	6.40±0.71 (4-8)	5.80±0.59 (4-8)	6.20±1.12 (4-10)	1.80±0.20 (1-2)	3.00±0.27 (2-4)	2.80±0. (2-3)	2.20±0.39 (2-4)
Pre- soaking In water (Hydro-priming)	4.80±0.21** (4-5)	7.20±0.32 (6-9)	6.40±0.60 (4-8)	6.40±0.51 (5-8)	2.60±0.21** (2-4)	3.20±0.18 (3-4)	3.00±0.48 (3-4)	3.00±0 (3-3)
K_2SO_4 0.5%	6,00±0.80 (3-8)	7.40±0.44 (6-9)	7.60±0.34* (6-8)	6.60±0.45 (5-6)	3.40±0.20** (3-4)	3.20±0.21 (3-4)	3.40±0.34* (3-5)	3.40±0.39* (2-4)
K_2SO_4 1.0%	6.40±0.52** (5-8)	7.40±0.71 (5-10)	7.40±0.21 (7-8)	7.20±.051 (6-9)	3.40±0.21** (3-4)	3.40±0.21 (3-4)	3.40±0.21** (3-4)	0.40±0.22** (3-4)
K_2SO_4 2.0%	6.80±0.51** (6-9)	7.80±0.51 (6-9)	7.20±1.18 (7-8)	7.20±0.21 (7-8)	3.40±0.18** (3-4)	3.80±0.28** (2-4)	3.40±0.20** (3-4)	3.60±0.32** (3-5)
K_2SO_4 4.0%	5.70±0.22** (5-6)	7.20±0.71 (4-9)	7.00±0.48 (6-9)	7.00±1.01 (4-10)	3.00±0.32** (2-4)	3.20±0.27 (2-4)	3.20±0.18** (3-4)	3.00±0.74 (1-5)
K_2SO_4 8.0%	3.80±0.18 (3-4)	6.80±0.51 (6-9)	7.00±0.74 (4-9)	6.80±0.77 (4-9)	2.80±0.18** (2-3)	3.00±0 (3-3)	3.00±0 (3-3)	3.00±0 (1-5)
K_2SO_4 16.0%	2.80±0.18** (2-3)	6.40±0.71 (4-9)	6.80±0.59 (4-8)	6.60±0.44 (5-8)	2.80±0.21** (2-4)	2.80±0.18 (2-3)	2.80±0.20 (3-4)	3.00±0 (3-3)

*, ** :Significant at 5% and 1% levels, respectively. #figures in parentheses indicate values of range.

Table 3. Effect of K_2SO_4 treatments for 24 h on seedling height and root length in 4 maize genotypes

Treatment (Seed priming)	Seedling height (cm)				Root length (cm)			
	4212	32A09	k-26	G-2	4212	32A09	k-26	G-2
Control (No pre-Soaking)	13.00±0.66 (11-15)#	26.20±1.00 (25-33)	25.40±1.83 (13-28)	25.20±4.98 (3-33)	10.50±0.68 (9-13)	23.00±1.15 (18-25)	20.20±1.45 (19-29)	18.60±3.70 (3-27)
Pre- soaking In water (Hydro-priming)	23.60±3.64 (16-23)	28.40±1.1232 (25-31)	29.40±1.30 (24-33)	26.20±4.98 (3-33)	16.75±1.18** (13-20)	24.00±1.26 (17-25)	22.80±0.96 (20-26)	21.00±3.70 (3-27)
K_2SO_4 0.5%	26.40±0.52** (25-28)	28.80±1.10 (26-33)	32.50±1.02 (26-35)	27.20±1.18 (24-30)	17.25±3.02** (10-22)	26.00±0.87 (23-29)	24.80±1.10 (20-27)	22.00±3.61 (6-28)
K_2SO_4 1.0%	28.00±3.01 (5-8)	30.00±2.37 (5-10)	31.20±0.65 (7-8)	30.80±1.55 (6-9)	22.20±0.96** (3-4)	27.20±2.24 (3-4)	23.80±1.96 (3-4)	23.00±1.86 (3-4)
K_2SO_4 2.0%	32.50±0.76** (30-35)	33.20±0.89* (28-35)	31.20±0.65 30-33)	32.50±039 (30-33)	23.00±1.24** (20-27)	27.80±1.82 (21-33)	23.40±1.33 (20-30)	25.50±0.83 (23-28)
K_2SO_4 4.0%	31.40±0.91** (28-33)	28.60±2.94 (16-35)	30.20±0.75 (27-34)	31.80±0.43 (30-33)	18.80±0.33** (18-20)	27.50±1.30 (25-33)	22.00±1.96 (21-23)	23.60±1.18 (18-24)
K_2SO_4 8.0%	28.00±3.01 (17.33)	28.40±2.01 (27.31)	29.80±1.30 (24.33)	29.20±2.09 (23-33)	18.60±3.14 (6-27)	26.80±1.03 (21-27)	20-20±1.15 (11-25)	22.40±0.95 (21-26)
K_2SO_4 16.0%	17.60±3.32 (15-33)	27.90±1.42 (23-30)	27.80±2.68 (16-33)	28.00±2.25 (21-33)	16.60±2.03 (11-23)	24.80±1.97 (19-30)	2.00±1.96 (20-28)	20.80±1.17 (17-25)

*, ** :Significant at 5% and 1% levels, respectively. #figures in parentheses indicate values of range.

treatments with 79.2% germination compared to 53.5% in control i.e. an improvement of 48% over that of control. In other genotypes also there was increase in germination upon seed priming with K_2SO_4 salt solution particularly at lower concentrations (Table 1). Similar increases in germination upon seed priming of rice seed with KH_2PO_4 at 4.0% was reported by Borgohain and Phukon, 1994. Seed priming with inorganic salt K_2SO_4, particularly at 2.0% concentrations for 24h duration has a significant positive effect on the seedling growth with marked increases in seedling fresh weight and dry weight (Table 1). However, the response was not of same magnitude in all the maize genotypes tested with '4212', '32A09' and 'K-26' exhibiting very strong response while 'G-2' responding very mildly. Similar observations of better seedling growth in polyethylene glycol (PEG) treated seeds of tomato were earlier reported by Saxena and Singh, 1987. K_2SO_4 at 1.0 and 2.0% concentrations helped in increasing the germination percentage, seedling length, fresh and dry weights compared to the untreated seeds similar to PEG. Similarly, the germination was significantly high in maize seeds primed with water absorbed pearlstone (52-92%) than in controls (36 - 70%); chilling resistance and root fresh wt were increased by seed treatments (Zhang, 1991).

Significant increases were recorded in the no. of roots and leaves per seedling and seedling root and shoot lengths upon seed priming with K_2SO_4 salt (at 2%) compared to untreated controls of maize (Tables 2 and 3). Among the four maize genotypes, maximum (positive) response was recorded for the genotypes '4212' for all the seedling parameters studied. Earlier, Nagar *et al.*, 1998, also observed increased response of maize seed to priming with thiram (0.2%) in seedling emergence, field stand and plant growth. The results of our study clearly suggest that seed priming of maize seed with K_2SO_4 salt solution at 2% concentration for 24h each is beneficial for improving seed germination, and seedling growth.

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VARIABILITY AND GENETIC DIVERGENCE OF AROMATIC RICE (*ORYZA SATIVA* L.)

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ABSTRACT

Seventy one genotypes of aromatic rice (*Oryza sativa* L.) from Madhya Pradesh and Chhattisgarh region were studied for genetic parameters and genetic divergence. The genetic parameters computed indicated that selection of genotypes may be done for fertile spikelet/panicle, spikelet density, spikelet sterility percentage and hundred seed weight. The genotypes were grouped into eight clusters using Mahalanobis D^2 statistics and showed that genetic diversity was not related to geographical diversity. Based on divergence and superior cluster means, genotype Tulsi Mala for fertile spikelet/panicle and spikelet density of cluster II, Shankar Jeera of cluster VII for hundred grain wt. and head rice recovery and Lohandi for grain yield and Til Kasturi for ear bearing tillers of cluster VIII were found superior. Hence, these genotypes may be used as parents for further breeding programmes.

Key words : Rice, aromatic, variability, genetic divergence.

Rice is the most important and extensively grown food crop of the world in general and of India in particular. India ranks second in rice production. Aromatic rice fetches premium price due to its aroma, excellent cooking quality and taste and preferred for export. However, its share in international market is very less due to deficient in cooking and eating quality. Thus, needed intensive efforts to improve yield as well as quality of aromatic rice to earn more foreign exchange. The success of any crop improvement will largely depend on the magnitude and range of variability and diversity in the available genetic stock. A critical estimate of genetic variability and divergence is prerequisite for initiating appropriate breeding in crop improvement programme. Hence, in the present investigation, attempts have been made to estimate genetic parameters and divergence for different yield and quality characters in the available aromatic rice.

MATERIALS AND METHODS

The experimental materials consisted of seventy one rice germplasm lines from Madhya Pradesh and Chhattisgarh. The experiment was conducted during *kharif* 2001 at Research Farm, Indira Gandhi Agricultural University, Raipur. The experiment was laid out in complete randomized block design with two replication. Twenty one days old seedlings from the nursery were transplanted in a three rows of 2 m length adopting spacing of 20x15 cm. The recommended package of practices were adopted for growing the crop. The observations were recorded from ten randomly selected plants in each replication for 10 quantitative traits to estimate the genetic parameters. Genotypic and phenotypic coefficient of variation and heritability were calculated by using formula of Burton, (1952) and Johnson *et al.* (1955) respectively. To measure the genetic divergence (Rao, 1952) fourteen characters were recorded on ten randomly selected plants and the mean value were subjected to Mahalanodis D^2 statistics and the clusters were formed by Tocher's method.

RESULTS AND DISCUSSION

Analysis of variance showed highly significant differences for all the characters. Genetic parameters *viz.*, genotypic and phenotypic coefficient of variation, heritability and genetic advance are presented in Table 1. In general, estimates of phenotypic coefficient of

Table 1. Estimates of genetic parameters for quantitative traits in aromatic rice

Characters	Mean	Range	GCV (%)	PCV (%)	Heritability h2(bs)	Genetic advance as percent of mean (%)
Plant height (cm)	108.7	42.8-146.0	15.3	15.4	98.0	31.1
Panicle length (cm)	22.6	16.6-26.9	11.1	12.5	79.5	20.5
Ear bearing tillers	7.3	4.5-10.5	13.0	20.0	42.1	17.3
Fertile spikelet/panicle	131.3	73.0-215.5	26.7	29.5	82.3	49.9
Spikelet density	6.8	3.9-11.7	25.1	28.9	75.4	44.9
Spikelet sterility %	14.1	3.8-38.1	48.5	55.5	76.6	37.6
Hundred seed wt.	1.4	0.9-3.0	28.5	28.9	97.6	58.1
Head rice recovery (%)	65.5	51.4-73.7	6.0	8.1	55.2	9.2
Harvest index	44.9	29.9-57.5	12.7	15.9	64.6	21.1
Grain yield/plant (g)	17.5	8.3-26.7	22.0	25.1	76.7	39.7

variation (PCV) were higher than genotypic coefficient of variation (GCV) for all characters. This view had also been reported by Das et al. (2001). However, relatively smaller differences between GCV and PCV for these characters indicated that these were mostly governed by the genetic factors. Estimates of GCV were high for spikelet sterility percentage, hundred seed weight, fertile spikelet/panicle density and grain yield/plant conforming the earlier reports (Nath and Talukdar, 1997; Rather *et al.*, 1998). These findings suggested the possibility of yield improvement through selection of these traits. High heritability coupled with genetic advance will be more useful in selection (Johnson *et al.*, 1955). In the present investigation, high heritability coupled with high genetic advance observed for hundred seed weight, fertile spikelet/panicle, spikelet sterility percentage, spikelet density and grain yield/plant indicated that these characters were predominantly governed by additive gene action. Similar results for hundred seed weight was reported earlier by Verma *et al.* (2000); spikelet sterility percentage was observed by Nath and Talukdar, (1997); spikelet density by Chauhan *et al.* (1993) and grain yield/plant Manual and Prasad, (1993).

The frequency distributions for 12 agro-morphological traits were also studied. A majority of genotypes were found to posses predominantly green basal leaf sheath colour, green leaf blade colour, green leaf tip colour, green leaf margin colour, green collar colour, while ligule colour, light green auricle colour, white apiculus colour, white stigma colour and white sterile glume colour. Plant habit included mostly semi-erect types and for awning character most of the genotypes were found to be awnless.

On the basis of D^2 values, all the seventy one genotypes were grouped into 8 clusters (Table 2). The maximum numbers of genotypes were in cluster III whereas cluster VII contained only 2 genotypes. In each cluster, the genotypes included were from different origin indicating that there is no association between clustering pattern and geographical distribution of the genotypes. Many workers (Mishra and Dash, 1997; Shanmugasundaram *et al.*, 2000) have revealed that geographical diversity is not necessarily related to genetic diversity.

On the other hand many genotypes originating from one place were scattered over different clusters. Such genetic diversity among the genotypes of common geographic origin could be due to factors like heterogeneity, developmental traits, past history of selection and degree of GCA. The intra and inter cluster divergence among the genotypes was of varying magnitude (Table 3). The highest intra cluster D^2 value (3.00) was recorded in cluster VII followed by IV, III and I. The maximum inter-cluster distance was obtained between cluster VI and VII (6.51) while the minimum has been observed between cluster III and V (2.42) indicating close relationship between these clusters. The greater the distance between clusters, wider the genetic diversity between the genotypes.

The cluster means for each character are presented in Table 4. The genotype, Shankar Jeera, in the cluster VII showed the highest hundred seed weight, milling percent and head rice recovery whereas, Bhata Dubraj of same cluster showed highest harvest index and lowest plant height. Lohandi in cluster VIII showed the

Table 2. Distribution of rice genotypes in different clusters

Cluster No.	No. of genotypes	Genotypes	Origin/source
I	12	Jata Shankar, Chinoor, Dubraj, Ganga Prasad, Shonth, Jeelo, Dudh Dhan, Deshi Dubraj, Rajim-14, Tulsi Bar, Bishnubhog, Banaspaati	Bilaspur (2), Seono, Shahdol (3), Ambikapur (2), Mandla, Raipur (3)
II	12	Ganga Balu, Dhawara Sawa, Samudra Fan, Jauphool, Jeera Shankar, Badshah, Chini Kapoor, Ganga Baru, Dumar Phool, Samund Chins, Tulsi Mala, Laxmibhog	Raipur (3), Bilaspur, Raigarh, Mandla, Bastar (4), Ambikapur (2)
III	17	Kubri Mohr, Badshshbhog, Kalajira, Samund Chini, Tulsi Manjari, Kapoor Sar, Fundri, Badar Phool, Sevanti, Kadam Phool, Badarpur, Sarsaraiya, Shahjira, Shyam Jira, Kabri Mohari, Harun Dubraj, Lallu	Raipur (3), Bastar (3), Ambikapur (3), Rajnandgaon (2), Balaghat (3), Mandla, Raigarh, Hosangabad
IV	6	Anterved, Kalimuchh, Banspatri, Kari Gilas, Talsani, Sukra Phool	Damoh, Gwalior, Raipur, Bastar, Dindori, Raigarh
V	9	Lalloo-14, Kadam Phool, Atmashital, Waasmati, Shitalbhog, Vishnubhog, Tulsi Amrit, Jira, Kadam Phool	Bastar (5), Sidhi, Raigarh, Ambikapur, Balaghat
VI	5	Vishnubhog, Loktimachhi, Shri Kamal, Tulsi Prasad, Kali Kamod	Ambikapur (2), Bastar (2), Jabalpur
VII	2	Shankar Jeera, Bhara Dubraj	Balaghat, Rajnandgaon
VII	8	Bhata Phool, Til Kasturi, Shukla Phool, Lahsunbhog, Lohandi, Jan Phool, Thakur Prasad, Chhatri	Sidhi, Raipur, Bilaspur, Bastar, Dindori,Raigarh, Ambikapur, Jabalpur

Table 3. Average intra (bold) and inter cluster distance among eight clusters

Cluster	I	II	III	IV	V	VI	VII	VII
I	2.82	4.27	4.28	3.68	3.39	4.30	3.70	3.49
II		2.46	3.80	4.96	3.34	3.77	5.56	2.86
III			2.91	3.21	2.42	4.41	4.13	3.77
IV				2.95	3.72	4.12	4.07	3.32
V					2.31	3.93	4.59	3.34
VI						2.38	6.51	3.59
VII							3.00	4.59
VIII								2.58

Table 4. Mean values of the characters of the clusters

Characters	I	II	III	IV	V	VI	VII	VIII
Plant height (cm)	100.66	117.81	105.53	118.7	102.7	134.80**	69.22*	118.94
Panicle length (cm)	19.94*	23.91	22.52	24.47	20.1	25.91**	20.55	24.54
Ear bearing tillers	6.62*	7.92	6.85	7.25	7.44	7.7	7.4	8.12**
Fertile spikelet/panicle	153.17	180.96**	101.12	97.94*	117.72	160.2	107	133.62
Spikelet density	8.25	9.09**	5.65	4.59*	6.51	7.31	6.6	6.33
Spikelet sterility (%)	10.20*	15.45	20.59**	14.91	10.48	15.04	19.24	13.01
Hundred seed weight	1.8	1.06*	1.32	1.77	1.15	1.27	1.86**	1.3
Biological wt./plant (g)	42.67	41.83	32.62*	39.56	39.67	43.3	36.8	45.88**
Milling percent (%)	71.95*	75.49	73.93	73.21	73.12	69.27	75.78**	74.69
Kernel length (cm)	8.23	5.91*	6.71	8.6	6.31	6.88	8.95**	6.93
Length: breadth ratio	3.73	2.90*	3.18	4.15**	3.18	3.3	4.01	3.44
Head rice recovery	64.24	67.66	66.11	64.98	63.23	57.60*	69.57**	68.04
Harvest index	49.18	44.09	42.22	43.22	40.2*	43.46	50.64**	49.46
Grain yield/plant (g)	20.19	18.08	13.29*	16.66	15.99	19.36	18.44	22.99**

highest grain yield performance accompanied by biological yield/plant whereas, ear bearing tillers was maximum in Til Kasturi. The maximum fertile spikelet/panicle and spikelet density were found in genotype, Tulsi Mala, of cluster II. Cluster VI means showed maximum plant height and panicle length for the genotypes it contained. The genotypes of cluster I were characterized by lowest panicle length, ear bearing tillers, spikelet sterility percentage and milling percent. The genotypes in cluster V possessed medium values for most of the characters. The coefficient of variance for different characters indicated that major forces of discrimination were spikelet sterility percentage, hundred seed weight, spikelet density, grain yield/plant, fertile spikelt/panicle and ear bearing tillers which is in agreement with the findings of Mishra and Dash (1997).

Parents combing high yield potential with wide genetic diversity are likely to yield superior segregates. Thus, combining parent of Tulsi Mala belonging to cluster II; Shankar Jeera of cluster VII and Til Kasturi and Lohandi of cluster VIII would result in high heterotic expression. This information may be useful to the breeders in varietal improvement programme of the Madhya Pradesh and Chhattisgarh region.

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EFFECT OF DIFFERENT LEVELS AND SOURCES OF NITROGEN ON GROWTH AND YIELD OF BASMATI RICE (*ORYZA SATIVA*)

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ABSTRACT

An experimental was carried out during rainy seasons (July- November) 2003 and 2004 at Crop Research Farm Department of Agronomy, Allahabad Agricultural Institute -Deemed University, Allahabad, on sandy loam soil to evaluate, the effect of different levels and sources of nitrogen on growth of different levels and sources of n nitrogen on growth and yield of two varieties of Basmati rice (*Oryza sativa* L.) cv. Pusa Basmati-1 and Haryana Basmati. The experiment was laid out in 2x3x3 factorial randomized block design with, eighteen treatments & three replications. It was observed that Pusa Basmati-1 proved significantly higher values of growth and yield attributes and resulted in 8 percent higher grain yield. Nitrogen 90 kg ha^{-1} exhibited higher growth and yield parameters and registered 19 percent and 43 percent higher grain yield over 60 kg N ha^{-1} and 30kg N ha^{-1}, respectively. Among the sources urea appeared more appropriate and yielded 20 percent and 10 percent higher grain yield over a source of poultry manure and urea (50% +) poultry manure (50% +), respectively. Interaction effects further indicated that variety Pusa Basmati 1 treated with 90 kg N ha^{-1} through urea alone was more appropriate combination to realize higher yield from basmati rice.

Key words : Basmati rice, nitrogen, sources, growth, yield.

Rice is the world's leading crop occupy over an about 145 million hectare. About 90 percent of rice grown in the world is produced and consumed in the Asian region. The United Nations General Assembly (UNGA) declared 2004 as the international year of rice (Mangla Rai, 2004). Basmati rice also known as "Queen of rice" contributes a major share in the total agricultural exports in our country. Nitrogen is essential plant nutrient a must for getting good yield or rice (Thakur, 1989). Use of inorganic fertilizers has become essential part of the crop production and a balanced fertilizer use is always a prerequisite to obtain higher yield. The present investigation was under taken to ascertain the suitable levels of nitrogen and optimum source for producing highest grain yield.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* sesons 2003 and 2004 at Crop Research Farm Department of Agronomy, Allahabad Agricultural Institute-Deemed University Allahabad, is situated at 25.57 north latitude and 81.6 east longitude and at on altitude of 90m above mean sea level. The experiment was laid out in 2x3x3 factorial randomized block design with eighteen treatments with three replications. Treatments consisted of two varieties (Pusa Basmati-1 and Haryana Basmati) three levels of nitrogen (30, 60 and 90kg ha^{-1}) and three sources (Urea, Poultry manure and Urea (50%)+ Poultry manure (50%)). The soil was sandy loam with pH. 7.5. Full dose of poultry manure was applied before transplanting as per treatment need. Urea was used as basal as per treatment need. A uniform does of P @ 60 kg ha^{-1} (SSP) and K @ 60 kg ha^{-1} (MOP) was given in all plots at the time of transplanting along with half dose of nitrogen though urea, remaining ½ dose of nitrogen through urea were applied (1/4 at maximum tillering and ¼ at panicle initiation stage. The observation were recorded on plant height, number of tillers/ hill, dry weight , number of filled grains/ panicle , test weight , harvest index, grain yield straw yield & biological yield. The crop is grown assured irrigated conditions.

RESULTS AND DISCUSSION

Varieties

Varieties significantly influenced the growth parameters, yield attributes and yield parameters (Tables 1, 2 and 3). Pusa Basmati produced highest plant height, number of tillers/ hill, dry weight, number of filled grains / panicle, test weight, harvest index, grain yield, straw yield and biological yield than Haryana Basmati. Pusa Basmati gave significantly higher grain yield 29.58q ha^{-1} and 31.02q ha^{-1} during 2003 & 2004, respectively than Haryana basmati. The higher gain yield under variety Pusa Basmati-1 might be due to its superiority than Haryana Basmati. (Behra, A.K, 1998, Singh *et al.*, 1997).

Nitrogen

Application of 90 kg N ha^{-1} significantly increased the plant height, number of tillers/ hill and dry weight over 30 and 60 kg N ha^{-1} (Table 1). The significant increase in growth parameters with the application of nitrogen might be due to its pivotal role in several physiological and biochemical processes *viz,* root development, photosynthesis, energy transfer reaction, (Bindra, *et al.*, 2000; Kumar *et al.*, 2001). Application of nitrogen up to 90 kg ha^{-1} increased the yield attributes, number of filled grain/ panicle, test weight and harvest index (Table 2) as well as yield parameters, grain, straw and biological yield over 30 and 60 kg N ha^{-1} (Table 3). 90 kg N ha^{-1} gave significantly higher grain yield (35.78q ha^{-1}) and 37.88q ha^{-1} during 2003 and 2004, respectively than 30 and 60 kg N ha^{-1} increase in yield attributes and yield parameters with the increasing levels of nitrogen was also reported by Pal *et al.* (2002), Satsongi, (2002) and Singh *et al.* (1997)

Sources

Nitrogen through urea produced significantly higher growth parameters and yield attribute (Tables 1&2). Nitrogen through urea gave significantly higher grain yield (31.88q ha^{-1}), (32.78q ha^{-1}) and followed by urea + poultry

Table 1. Effect of different levels and sources of nitrogen on growth parameters of *Basmati* rice

Treatments	Plant height (cm)		Number of tillers/hill		Dry weight (g)	
	2003	2004	2003	2004	2003	2004
Varieties						
Pusa Basmati-1	81.92	83.38	9.35	9.51	37.70	38.74
Harayana Basmati	75.96	76.74	8.72	8.86	31.96	33.20
S.Em±	0.49	0.12	0.028	0.026	0.50	0.87
CD at 5%	1.00	0.25	0.058	0.052	1.014	1.77
Nitrogen rate (kg ha^{-1})						
30	68.77	70.11	7.29	7.47	24.62	24.86
60	82.00	83.28	9.70	9.56	37.61	38.39
90	86.06	86.80	10.16	10.24	42.27	44.67
S.Em±	0.06	0.15	0.035	0.032	0.61	1.06
CD at 5%	1.22	0.31	0.071	0.064	1.24	2.16
Sources						
Urea	83.32	84.80	9.72	9.88	38.72	39.84
Poultry manure	73.27	73.77	8.12	8.22	30.27	31.47
Urea + PM	80.21	80.61	8.29	9.45	35.50	36.60
S.Em±	0.60	0.15	0.035	0.032	0.61	1.06
CD at 5%	1.22	0.31	0.071	0.064	1.24	2.16

Table 2. Effect of different levels and sources of nitrogen on yield parameters of different *Basmati* rice

Treatments	Number of filled grains/panicle		Test weight (g)		Harvest index (%)	
	2003	2004	2003	2004	2003	2004
Varieties						
Pusa Basmati-1	91.85	96.15	19.60	1972	39.34	39.18
Harayana Basmati	80.92	84.40	18.92	19.08	38.98	38.72
S.Em±	0.36	0.35	0.10	0.08	0.11	0.09
CD at 5%	0.73	0.70	0.21	0.17	0.23	0.18
Nitrogen rate (kg ha^{-1})						
30	61.32	64.44	18.08	18.12	37.22	37.02
60	92.05	95.77	19.32	19.48	39.14	38.74
90	105.77	110.61	20.38	20.58	41.12	41.12
S.Em±	0.44	0.42	0.13	0.10	0.14	0.11
CD at 5%	0.90	0.86	0.26	0.21	0.29	0.22
Sources						
Urea	96.77	102.77	20.11	20.35	40.38	40.54
Poultry manure	71.28	72.72	18.36	18.38	37.94	97.56
Urea + PM	91.11	95.33	19.34	19.46	39.14	38.78
S.Em ±	0.44	0.42	0.13	0.10	0.10	0.11
CD at 5%	0.90	0.86	0.26	0.21	0.29	0.22

Table 3. Effect of different levels and sources of nitrogen on grain yield, straw yield and biological yield of different *Basmati* rice

Treatments	Grain yield (qha^{-1})		Straw yield (q ha^{-1})		Biological yield (q ha^{-1})	
	2003	2004	2003	2004	2003	2004
Varieties						
Pusa Basmati-1	29.58	31.02	44.40	46.82	74.55	78.41
Harayana Basmati	27.62	28.70	43.14	44.10	70.28	73.44
S.Em±	.12	.13	0.12	.16	0.18	0.24
CD at 5%	.25	.26	.24	.33	0.37	0.48
Nitrogen rate (kg ha^{-1})						
30	20.78	21.32	34.53	35.75	55.75	57.54
60	29.28	30.36	44.97	47.31	74.67	78.25
90	35.78	37.88	50.33	53.33	86.84	92.00
S.Em±	.15	.16	.14	.20	0.24	0.29
CD at 5%	.31	.32	.29	.40	0.45	0.59
Sources						
Urea	31.88	32.78	45.94	46.92	98.33	80.17
Poultry manure	25.38	26.80	40.62	43.58	66.50	70.96
Urea + PM	28.5	30.01	43.24	45.88	74.42	76.66
S.Em±	.15	.16	.14	.20	0.24	0.29
CD at 5%	.31	.32	.29	.40	0.45	0.59

manure (28.88q ha^{-1}), (30.01q ha^{-1}) during 2003 and 2004 respectively then poultry manure alone. These results are in close conformity with the findings of Jadhav *et al.* (1998) and Mohammad Usman *et al.* (2003).

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SCREENING OF PARENTAL LINES AND THEIR F_1 CROSSES OF TOMATO (*LYCOPERSICON ESCULENTUM* MILL.) TO RALSTONIA WILT

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Abstract

Out of 8 parental lines and 28 F1 crosses of tomato (*Lycopersicon esculentum* Mill.) tested during 2001 and 2002 in bacterial wilt sicj plots, 6 parents viz., Hawaii-7998, BT-18, BL-333, TBL-4, CRA-66 and EC-191536 were found resistant to *Ralstonia* wilt [*Ralstonia solanacearum*(Smith)] in all the 2 years of testing. Based on the mean of 2 years data (2001-2002), 23 out of 28 F1crosses viz., Hawaii-7998 x BT-18 (96.67%), Hawaii-7998 x TBL-4 (91.67%), BT-18 x CRA-66 (88.33%), EC-191536 x Hawaaii-7998 (87.50%), EC-191536 x CRA-66 (87.50%), Hawaii-7998 x Roma (87.50%), BT-18 x Roma (86.68%), Hawaii-7998 x CRA-66 (86.67%), Hawaii-7998 x Solan Gola (85.83%), EC-191536 x BL-333 (85.00%), Hawaii-7998 x BL-333 (84.16%), BL-333 X BT-18 (84.16%), BL-333 x Roma (84.16%), BL-333 x CRA-66 (83.33%), EC-191536 x BT-18 (82.50%), EC-191536 x TBL x TBL-4 (82.50%), BL-333 x TBL-4 (82.50%), BT-18 x Solan Gola (82.50%), CRA-66 x TBL-4 (82.50%), TBL-4 x Solan Gola (81.67% %, EC-191536 x Solan Gola) (80.83%), EC-191536 x Roma (80.83%) and BT-18 x TBL-4(80.83%) showed resistant reaction and only one F1 cross BL-333 x Solan Gola (65.83%) gave moderately resistant reaction to Ralstonia wilt. The line EC-191536 has been released as Palam Pride from CSK HPKV. Palampur for bacterial wilt prone areas of the state.

Key words : Tomas, *Ralstonia solanacearum*, resistant, parental line, F_1 crosses

Tomato is one of the most popular vegetables, being grown all over the world. Mid-hills of Himachal Pradesh are playing a leading role in supplying off-season tomato to the plains during the lean period (June to October). Presently, commercial cultivars or hybrids are being grown by the farmers to exploit this fruitful situation. However, majority of these cultivars or hybrids succumbs to the pressure of bacterial wilt caused by *Ralstonia solanacearum* (Smith) resulting in partial to complete failure of the tomato crop (Bose and Rajan, 2000). As a matter of fact, this disease is posing a serious threat to the tomato cultivation in mid hill sub-humid and tropical areas in general (Villareal, 1980) and Mandi, Kangra, Kullu, Hamirpur and Solan districts in particular (Kalha *et al.*, 1993). The disease is manifested at all stages of crop growth with the maximum severity occurring during the flowering stage. The first step in this endeavor will be to identify suitable resistance sources and consequently utilizing these in suitable breeding programme (s) to breed disease-resistant cultivars or hybrids having high yields and acceptable quality is the need of the day. Hence, an attempt was made to screen the parental lines and their F_1 crosses of tomato for resistance to Ralstonia wilt.

Materials and Methods

Eight genetically diverse parents *viz.* EC-191536 (AVRDC, Taiwan), Hawaii-7998 (USA), CRA-66 (Guadeloupe), TBL-4 (Phillipines), Solan Gola (UHF, Solan), BL-333 (OUAT, Bhubaneswar), BT-18 (OUAT, Bhubaneswar), and Roma (IARI, Katrain), former 5 being indeterminate and later 3 being determinate in growth habit were crossed in a diallel set of n(n-1) /2 possible combinations in summer 2000. The four weeks ole seedlings of 8 parents and 28 F_1 hybrids were transplanted in sick plots during summer seasons of 2001 and 2002 at the Research Farm Regional Station, Bajaura, in randomized block design with 3 replications at spacing of 60 cm x 45 cm in two rows of 4.5 m length. A row of susceptible variety Roma was also planted after every 12 rows to ensure the uniform inoculation throughout the experimental field. To avoid the escapes, all the plants were also inoculated artificially at the time of transplanting with the inoculum of the most prevalent boivar-3 race-1 of Ralstonia solanacearum. The observations of plant survival on every 10 days were recorded and bacterial ooze test was also carried out on wilted plants to confirm the disease. The plant survival (per cent) at 90 days after transplanting was statistically analyzed and used for disease reaction following the scale of Mew and Ho 1976.

RESULTS AND DISCUSSION

Reaction of parental lines

Six parental lines *viz.*, Hawaii-7998, BT-18, BL-333, TBL-4, CRA-66 and EC-191536 showed highly significant differences in plant survival during both the years of testing (Table 1). Of the 8 parental lines tested during 2001, 6 parents showed resistant reaction while the two commercial cultivars namely Solan Gola and Roma as expected gave highly susceptible reaction to Ralstonia wilt. Quite similar trend was observed during second year of testing (2002). Out of 6 resistant lines, EC-191536 has been released as Palam Pride from CSK HPKV, Palampur for bacterial wilt prone areas of the state. Further, all the 6 resistant lines used in the present investigations were also identified as resistant donor parents from Palampur by Sharma and Verma (2002). The line Hawaii-7998 was also tested in various locations under AICVIP (Resistant varietal Trial) and reported to be the best performer in wilt resistance at various locations and higher yielder line (IIVR, 2002).

Reaction of F_1 crosses

The 28 F_1 crosses exhibited varying degrees of Ralstonia wilt resistance (Table 1). Out of 28 F1 crosses tested during 2001, 13 F1 crosses viz., Hawaii-79987 x BT-18, EC-191536 x Hawaii-7998, EC-191536 x CRA-66, EC-191536 x TBL-4, Hawaii-7998 x BL-333, Hawaii-7998 x CRA-66, Hawaii-7998 x TBL-4, Hawaii-7998 x Solan Gola, Hawaii-7998 x Roma, BL-333 x CRA-66, BL-333 x Roma, BT-18 x CRA-66 and BT-18 x Solan Gola showed resistant reaction and 11 crosses viz., EC-191536 x BL-333 x BL-333, EC-191536 x BT-18, EC-191536 x Solan Gola, EC-191536 x Roma, BL-333 x BT-18, BL-333 x TBL-4, BT-18 x TBL-4, Roma, CRA-66 x TBL-4, CRA-66 x Roma and TBL-4 x Splan Gola were moderately resistant to Ralstonia wilt. During the second year testing (2002) 22 out of 28 F_1 crosses *viz.*, Hawaii-7998 x BT-18, Hawaii-7998 x Solan Gola, BT-18 x Roma, Hawaii-7998 x TBL-4, Hawaii-79988 x CRA-66, EC-191536 x BL-333,, BL-333 x BT-18, TBL-4 x Solan Gola, BL-333 x Roma, EC-191536 x Hawaii-7998, EC-191536 x BT-18, EC-191536 x CRA-66, BL-333 x TBL-4, BT_18 x TBL-4, CRA-66 x TBL-4, Hawaii-7998 x Roma, BL-333 x CRA-66, BT-18 x CRA-66, BT-18 x Solan Gola, EC-191536 x Solan Gola, EC-191536 x Roma and Hawaii-7998 x BL-333 were resistant and only two F_1 crosses namely EC-191536 x TBL-4, and BL-333 x Solan Gola were moderately resistant to Ralstonia wilt.

Based on the mean of 2 years data (2001-2002), 23 out of 28 F_1 crosses *viz.*, Hawaii-7998 x Bt-18 (96.67%). Hawaii-7998 x TBL-4 (91.67%), BT-18 x CRA-66 (88.33%), EC-191536 x Hawaii-7998 (87.50%), EC-191536 x CRA-66 (87.50%), Hawaii-7998 x Roma (87.50%), BT-18 x Roma (86.68%), Hawaii-7998 x CRA-66 (86.67%), Hawaii-7998 x Solan Gola (85.83%), EC-191536 x BL-333 (85.00%), Hawaii-7998 x BL-333 (84.16%), BL-333 x BT-18 (84.16%), BL-333 x Roma (84.16%), BL-333 x CRA-66 (83.33%), EC-191536 X BT-18 (82.50%), EC-191536 x TBL-4 (82.50%), BL-333 x TBL-4(82.50%), BT-18 x Solan Gola (82.50%), CRA-66 x TBL-4 (82.50%), TBL-4 Solan Gola (81.67%), EC-191536 x Solan Gola (80.83%), EC-191536 x Roma (80.83%) and BT-18 x TBL-18 (8083%) showed resistant reaction and lony one F_1 cross BL-333 x Solan Gola (65.83%) gave moderately resistant reaction to Ralstonia wilt. Sharma et al. (2005) also observed similar observations in brinjal. Mohankumaran *et al.* (1969) reported that higher tomato content was closely related with the surviving plants of tomato in wilt sick plots while Gopinath and Madalageri (1986) suggested that phenol content was closely related with the surviving plants in F1 generation. Phenols may play major role in the resistance mechanism of tomato to *Ralstonia* wilt (Kao and Hsiao, 1980).

Table 1. Plant survival and reaction of parental lines and their F1 crosses of Ralstonia wilt

Test line or parental line	90 days after transplanting					
	2001		2002		pooled	
	*Plant Survival (%)	**Disease reaction	Plant survival(%)	Disease reaction	Plant survival (%)	Disease reaction
1. EC191536	81.67 (64.67)	R	80.83 (64.34)	R	80.83 (64.34)	R
2. Hawaii-7998	95.00 (77.08)	R	98.33 (85.65)	R	96.67 (82.58)	R
3. BL-333	85.00 (67.21)	R	90.00 (71.52)	R	87.50 (69.65)	R
4. BT-18	88.33 (70.00)	R	96.67 (81.35)	R	92.50 (75.71)	R
5. CRA-66	85.00 (67.21)	R	80.83 (64.34)	R	85.50 (65.64)	R
6. TBL-4	86.67 (68.61)	R	85.00 (67.37)	R	85.83 (68.00)	R
7. Solan Gola	6.67 (15.00)	HS	6.67 (14.75)	HS	6.67 (14.75)	HS
8. Roma	6.67 (15.00)	HS	6.67 (14.75)	HS	6.67 (14.75)	HS
Cros						
EC-191536 x Hawaii-7998	90.00 (71.56)	R	85.00 (67.95)	R	87.50 (69.93)	R
EC-191536 x BL-333	80.00 (63.44)	MR	90.00 (74.96)	R	85.00 (69.39)	R
EC-191536 x BT-18	80.00 (63.44)	MR	85.00 (67.37)	R	82.50 (65.45)	R
EC-191536 x CRA-66	90.00 (71.56)	R	85.00 (67.95)	R	87.50 (71.46)	R
EC-191536 x TBL-4	85.00 (67.1)	R	80.00 (63.71)	MR	82.50 (65.89)	R
EC-191536 x Solan Gola	80.00 (63.44)	MR	81.67 (64.78)	R	80.83 (64.15)	R
EC-191536 x Roma	80.00 (63.44)	MR	81.67 (64.97)	R	80.83 (64.34)	R
Hawaii-7998 x BL-333	86.67 (68.61)	R	81.67 (64.78)	R	84.16 (66.70)	R
Hawaii-7998 x BT-18	95.00 (77.08)	R	98.33 (85.68)	R	96.67 (84.01)	R
Hawaii-7998 x CRA-66	81.67 (64.67)	R	91.67 (73.37)	R	86.67 (69.55)	R
Hawaii-7998 x TBL-4	90.00 (71.56)	R	93.33 (78.06)	R	91.67 (74.99)	R
Hawaii-7998 x Solan Gola	88.33 (70.00)	R	96.67 (81.35)	R	85.83 (68.39)	R
Hawaii-7998 x Roma	86.67 (68.61)	R	83.33 (66.11)	R	87.50 (69.65)	R
BL-333 x BT-18	78.33 (62.24)	MR	90.00 (71.92)	R	84.16 (67.09)	R
BL-33 x CRA-66	83.33 (65.88)	R	83.33 (66.81)	R	83.33 (66.46)	R
BL-33 x TBL-4	80.00 (63.44)	MR	85.00 (67.37)	R	82.50 (65.45)	R
BL-333 x Solan Gola	60.00 (50.77)	S	71.67 (57.83)	MR	65.83 (54.33)	MR
BL-333 x Roma	81.67 (64.67)	R	86.67 (68.63)	R	84.16 (67.18)	R
BT-18 x CRA-66	93.33 (75.21)	R	83.33 (65.92)	R	88.33 (70.56)	R
BT-18 x TBL-4	76.67 (61.14)	MR	85.00 (67.37)	R	80.83 (64.28)	R
BT-18 x Solan Gola	81.67 (64.67)	R	83.33 (66.11)	R	82.50 (68.44)	R
BT-18 x Roma	76.67 (61.14)	MR	96.67 (81.35)	R	86.68 (71.33)	R
CRA-66 x TBL-4	80.00 (63.44)	MR	85.00 (67.37)	R	82.50 (65.64)	R
CRA-66 x Solan Gola	53.33 (46.89)	S	56.67 (48.82)	S	55.00 (47.86)	R
CRA-66 x Roma	63.33 (52.71)	MR	50.00 (44.98)	S	56.67 (48.86)	S
TBL-4 x Solan Gola	70.00 (56.79)	MR	90.00 (71.92)	R	81.67 (66.09)	R
TBL-4 x Roma	41.67 (40.22)	S	36.67 (37.20)	HS	39.17 (38.69)	S
Solan Gola x Roma	6.67 (15.00)	HS	6.67 (14075)	HS	6.67 (14.75)	HS
CD at 5%	(13.52)		(9.87)		(7.12)	

*Figures in parenthesis are sine transformed values.

**Reaction scale (Mew and Ho. 1976)

R- Resistant (80-100% plant survival) MR- moderately resistant (60-79.99% plant survival); S- Susceptible (40-59.99% plant survival) and HS- highly susceptible (less than 40% survival).

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EFFECT OF RICE STRAW MULCHING ON WEED CONTROL IN JUTE (CORCHORUS OLITORIUS L.) UNDER *TERAI* AGRO-ECOLOGICAL REGION OF WEST BENGAL

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ABSTRACT

Field experiment was conducted at Uttar Banga Viswavidyalaya, Cooch Behar during *kharif* season of 2006 in order to study weed control methods in integrated weed management practices in jute. The treatments comprising fluchloralin 1.0 kg ha^{-1} as pre-emergence, fluchloralin 0.70 kg ha^{-1} as pre-emergence followed by hand weeding at 35 DAS, quizalofop ethyl (targa super) 50 g ha^{-1} as post-emergence at 21 DAS, quizalofop ethyl (whip super) 50 g ha^{-1} as post-emergence at 21 DAS, fenoxaprop ethyl (whip super) 50 g ha^{-1} as post-emergence at 21 DAS followed by hand weeding at 35 DAS, mulching with rice straw 8 ton ha^{-1} at 15 DAS after thinning and hand weeding, complete weed free and weedy control, have been tested in randomized complete block design with three replication. Weed flora of jute were comprised by sedges *Cyperus rotundus* L. and *Cyperus iria* L. and broadleaved weeds *Ageratum conyzoides* L. and *Ludwigia parviflora* (Roxb.). Among the weed control treatments mulching after thinning and hand weeding at 15 DAS was found highly effective in controlling weeds with high weed control efficiency value of more than 85% at any stage of crop growth. Therefore, this treatment became significantly at par with the complete weed free situation in terms of yield attributing characters and fibre yield. Fibre yield of 36 q ha^{-1} was obtained from rice straw mulching with only 1.66% yield reduction as compared to complete weed-free situation.

Key words : Mulching, weed control in jute, quizalofop ethyl (tagra super), ethyl (whip super), fluchloralin.

Jute is an important fiber crop in the terai region of West Bengal during *kharif* season. The availability of natural resources such as high rainfall during initial phage of the jute crop resulted in better germination and growth, medium to high temperature and high humidity during exponential growth phase of the crop and availability of water during harvest of jute for retting make this region ecologicaly suitable for jute crop. However, high humidity and high rainfall during *kharif* season cause high weed pressure of different weed flora (grass, sedge and broadleaved) which in turn offer strong competition to jute plants. Competition with weeds has been reported to cause 56% and 87% reduction in yield under irrigated and rainfed conditions, respectively (Saraswat and Sharma, 1983). Therefore, low yield of jute appeared to be attributed due to the heavy infestation of weed (Bandyopadhyay *et al.*, 1994). Manual weeding is a common weed control practice in this region, however, it incur huge expenditure as input cost and thus reduce benefits of jute cultivation (Saraswat and Mitra, 1976). This finding led to the need of studying cost effective weed control method in integrated weed management practices for controlling weeds in jute.

MATERIALS AND METHODS

Field experiment was carried out during *rabi* season of 2006 in the farm of Uttar Banga Krishi Viswavidyalaya with nine treatment combination. The treatments were comprised by fluchloralin 1.0 kg ha^{-1} as pre-emergence treatment, flucholarlin 0.71 kg ha^{-1} as pre-emergence treatment followed by hand weeding at 35 DAS, quizalofop ethyl 50 g ha^{-1} as post-emergence treatment as 21 DAS, quizalofop ethyl 50 g ha^{-1} as post-emergence treatment at 21 DAS followed by hand weeding at 35 DAS, fenoxaprop ethyl 50 g ha^{-1} as post-emergence treatment at 21 DAS, fenoxaprop ethyl 50 g ha^{-1} as post-emergence treatment at 21 DAS followed by hand weeding at 35 DAS, mulching with rice straw 8 ton ha^{-1} at 15 DAS after thinning and hand weeding, complete weed free and weedy control. These treatments were tested with three replications in RCBD (randomized complete block design). The variety JRO-524 was used with the spacing of 30 cm x 5 cm. Fertilizers with NPK ratio of 60:30:30 kg ha^{-1} were applied as basal. The experimental site was situated on medium land situation with high soil moisture content and the soil was sandy loam with pH 5.34-5.8 and organic carbon 1.02%. The available NO_3-N, NH_4-N, P and K were 117.80, 94.75, 16.35 and 76.9 kg ha^{-1}, respectively.

RESULTS AND DISCUSSION

Weed flora and weed dynamics

Weed flora comprised mainly by sedges and broadleaved weed a characteristic nature of weed flora in medium land situation with high soil moisture content. At initial stage of jute the sedges *Cyperus rotundus* L. and *Cyperus iria* L. became dominant and constitute the important weeds during initial 40 DAS. Beyond this stage the growth of *Cyperus rotundus* L. and *Cyperus iria* L. did not increase where as emergence of broadleaved weeds *Ageratum conyzoides* L. and *Ludwigia parviflora* (Roxb.) took place 30 DAS and became dominant weeds at later part of the crop growth.

Weed control efficiency and weed index

All the herbicidal treatments alone or in combination with hand weeding were found ineffective in controlling weed throughout the crop growth and thus resulted in poor weed control efficient of the treatments. Low value of weed control efficiency and value of weed index of the herbicide treated plots indicated high growth rate of weed which, in turn, reduced fibre yield of jute through sever weed-crop competition (Table 1). Characteristic appearance of weed flora comprised by sedges and broadleaved weeds made the post-emergence herbicide quizalofop ethyl and fenoxaprop ethyl ineffective in controlling weeds as these herbicides shows phytotoxicity only on the grasses. Rainfall occurring after application of fluchloralin caused water stagnation in the field for shorter period of time resulting in leaching and persistence in the soil. High soil moisture favoured rapid emergence and aggressive growth of the weeds. Lowest dry weight of weed throughout the crop growth was recorded in mulching treatment, which was reflected as more than 85% value of weed control efficiency at any stage of crop growth. High value of weed control efficiency and low value of weed index of mulching treatment indicated lowest level of weed-crop competition as rice straw mulch interfered germination, emergence and further growth of weeds by depleting solar energy in which red light was an essential requirement for germination of weed seeds.

Yield attributing characters and yield

Among the treatments, mulching with rice straw found highly effective in controlling weeds and that resulted in high value of yield attributing characters and consequently fibre yield of jute without having any significance difference with complete weed-free condition (Table 2). Only 1.66% yield reduction occurred in mulching treatment due to presence of weed as compared to complete weed-free plot and this result indicated the effectiveness of rice straw mulching to combat weed problem in jute under terai agro-ecological region of West Bengal and it could help the poor farmers to reap maximum benefit by saving their crop from severe crop-weed competition.

Table 1. Effect of treatment on dry weigh of weeds, weed control efficiency at different days after sowing and weed index

Treatments	Dry weight of weeds (g/m^2) at different days after sowing				Weed control efficiency (%) at different days after sowing				Weed index
	30 DAS	60 DAS	80 DAS	at Harvest	30 DAS	60 DAS	80 DAS	at harvest	-
Fluchloralin 0.70 kg ha^{-1} + HW	156.23	138.21	182.25	176.41	13.80	36.96	28.27	24.67	46.11
Fluchloralin 1.00 kg ha^{-1}	143.21	189.21	216.97	205.12	20.99	17.77	14.61	12.42	58.34
Quizalofop ethyl 50 g ha^{-1} + HW	168.21	215.49	235.13	218.42	7.19	6.39	7.46	6.74	64.28
Quizalofop ethyl 50 g ha^{-1}	162.58	212.32	231.29	215.62	10.30	7.77	8.98	7.93	60.44
Fenoxaprop ethyl 50 g ha^{-1}	167.17	207.31	223.13	208.23	7.77	9.95	12.19	11.09	55.57
Fenoxaprop ethyl 50 g ha^{-1}	161.64	203.21	217.12	202.84	10.82	11.73	14.55	13.39	55.11
Mulching	17.23	23.58	27.89	29.11	90.49	89.75	89.02	87.57	1.66
Weedy control	181.26	230.22	254.11	234.21					
SEm ±	0.606	0.559	0.558	0.510					
CD (p=0.05)	1.837	1.696	1.693	1.549					

DAS-Days after sowing, HW- hand weeding

Table 2. Effect of treatments on yield attributing characters and fibre yield

Treatment	Plant height upto apex (cm)	Basal girth of stem (cm)	Fibre yield of jute (kg/ha)
Fluchloralin 0.70 kg ha^{-1} + HW	245	3.56	1980.00
Fluchloralin 1.00 kg ha^{-1}	211	3.20	1530.72
Quizalofop ethyl 50 g ha^{-1} + HW	194	3.01	1312.45
Quizalofop ethyl 50 g ha^{-1}	205	3.14	1453.57
Fenoxaprop ethyl 50 g ha^{-1}	216	3.33	1632.40
Fenoxaprop ethyl 50 g ha^{-1}	218	3.33	1649.05
Mulching	335	4.59	3613.50
Weedy control	180	2.77	1106.28
Complete weed-free	336	4.65	3674.62
SEm ±	1.472	0.027	1.049
CD (p=0.05)	4.412	0.082	3.146

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ASSESSMENT OF MAIZE GENOTYPES UNDER TERMINAL DROUGHT

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ABSTRACT

The single cross hybrids developed by crossing ten elite inbred lines with two drought tolerant exotic testers (*viz.* CML-341 and Pool 16 BN) in line x tester mating design, were evaluated along with parental lines and standard checks under rainfed (during *kharif* 2004); normal irrigation and terminal drought (during *rabi* 2004-05). Genotypes highly influenced by seasons and terminal moisture stress. Hybrids (F'_1s) exhibited higher grain yield, plant height and ear height along with earliness and narrow anthesis-silking interval (ASI) over parental lines under varying environments. The traits under investigation were controlled by additive and non-additive gene actions and thus could be improved through selection followed by hybridization. The good general combining inbreds with high per se performance for grain yield, earliness and various yield contributing traits were EI-569 in rainfed and EI-572 in irrigated, while EI-569 and EI-573 in terminal drought environments. Hybrids EI-570 x CML-341 EI-573 x Pool 16 BN EI-574 x Pool 16 BN and EI-578 x CML-341 under rainfed; EI-572 x CML-341 and EI-576 x CML-341 under irrigated and EI-571 x CML-341 and EI-569 x Pool 16 BN under terminal moisture stress, express superiority, since they exhibited higher estimates of *per se* performance, SCA effects, heterobeltiosis and economic heterosis for grain yield and its various attributes.

Key words : Exotic tester, terminal drought, moisture stress, genotypes, combining ability, heterobeltiosis and economic heterosis.

In Rajasthan, maize (*Zea mays* L.) is cultivated as rainfed crop in most of the growing areas. In semi-arid regions, it is greatly influenced by terminal drought and even high yielding, full season varieties/ hybrids show drastically reduced grain yield < 1.0 tone/hectare). Drought is a multi-dimensional stress, affecting plants at various levels of their organization. Maize is very sensitive to moisture stress. In this crop there are three important growth stages *viz.* germination, flowering (tasseling and silking) and dough stage. Among these flowering and dough stages are most critical stages. in relation to moisture stress. The improvement in yield potential under drought prone areas is possible only through development of drought tolerant/ resistant, high yielding and early maturing hybrids/varieties. An attempt has been made in this investigation to develop and identify superior single cross hybrids and good general combining inbreds, which are sustainable for semi-arid rainfed and terminal drought situations.

MATERIALS AND METHODS

Ten elite inbred lines (L_1=EI-569, L_2=EI-570, L_3=EI-571, L_4=EI-572, L_5=EI-573, L_6=EI-574, L_7=EI-575, L_8=EI-576, L_9=EI-577 and L_{10}=EI-578) were crossed with two drought tolerant exotic testers (*viz.* T_1=CML-341 and T_2=Pool 16 BN) in line x tester mating design to develop single cross hybrids. These hybrids along with parental lines (10 inbreds and 2 testers) were evaluated in randomized block design with 3 replications under 3 environments (E_1=Rainfed during *kharif* 2004; E_2=Normal irrigated during *rabi* 2004-05 and E_3=Terminal drought during *rabi* 2004-05) with a row to row and plant to plant spacing of 60 cm and 25 cm, respectively, in each environment. To judge the economic importance of inbreds and hybrids 3 standard checks (*viz.* CM-137, PEHM-2 and Navjot) were included in each environment. The experiments were conducted at the Instructional Farm, Rajasthan Collage of Agriculture, MPUAT, Udaipur. The observations were recorded for days to 50 per cent pollen shad, days to 50 per cent silking, days to 50 per cent maturity, anthesis-silking interval (ASI), plant height (cm), ear height (cm) and grain yield per plant (g). The good general combining inbred lines and superior hybrids were identified on the basis of per se performance; analysis of mean and variances (Panse and Sukhatme, 1964); combining ability analysis (Kempthrone, 1957); heterobeltiosis (Fonesca and Patternson, 1968) and economic heterosis (Meredith and Bridge, 1972).

RESULTS AND DISCUSSION

Analysis of Variance

The appropriate genetic variability among genotypes was recorded, SInce they exhibited highly significant estimates of variances for all the traits under varying environments and pooled analysis except ASI in E_1 (Table 1). Mean sum of squares due to environment were highly significant for all the traits indicated that environments were considerably differed from each other. Highly significant variances due to genotype x environment interaction suggested that genotypes highly interacted with environmental fluctuations. The higher estimates SCA variances over GCA variances and less than unity estimates of a σ^2_g / σ^2_g ratio, revealed that traits under study were controlled by both additive (σ^2_g) and non-additive (σ^2_s) gene actions, with preponderance of non-additive (σ^2_s) gene actions. Thus, these traits could be improved through selection followed by hybridization. Yadav *et al.* (2003) and Betron *et al.* (2003) also recorded similar trends for various yield attributes in maize.

The five top ranking parental lines and single cross hybrids were identified on the basis of per se performance, GCA and SCA effects, heterobeltiosis and economic heterosis for each trait under investigation:

Per se Performance:

It was observed that genotypes greatly influenced by seasons and terminal moisture stress, since greater differences in mean performance were recorded for all the traits under varying environments (Table 2). The mean performance of parental lines and hybrids for earliness (days to pollen shad, silking and maturity) revealed that parental lines L_1 and T_2 as well as hybrid L_5 x T_1 were performed better under rainfed. Inbred lines L_2 and L_5 along with hybrids L_2 x T_2 and L_7 x T_1 found better under irrigated, while inbreds L_1, L_3, L_5 and L_{10} and hybrids L_2 x T_2 and L_7 x T_1 were better under terminal drought. The antesis-silking interval (ASI) is an important trait in relation to drought tolerance. A genotype possessed narrow ASI may be considered as tolerant to moisture stress. Inbreds L_3 and L_4 showed reduced ASI under the entire environments, while hybrids L_1 x T_1 and L_1xT_2 possessed narrow ASI under rainfed and water stress conditions and supposed to perform better under terminal drought prone areas. Hybrid L_6 x T_1 found better under rainfed (*kharif* and irrigated (*rabi*). The parents as well as hybrids exhibited maximum plant height and ear height in *kharif* followed by irrigated and terminal moisture stress in *rabi*. Inbred L_4 and hybrid L_{10} x T_1 found better under all the environmental conditions for plant height, while inbred L_9 was superior under varying environments with low cob placement. The maximum grain yield per plant (g) was observed in irrigated followed by rainfed and terminal water stress for parental lines, while hybrids exhibited highest grain yield in irrigated followed by moisture stress and rainfed environments. Parental lines L_9, T_1 and T_2 performed better in varying environments, while inbreds L_2 and L_5 provided better grain yield under terminal moisture stress. Hybrid L_5 x T_2 exhibited better yield potential under rainfed and terminal drought, while hybrid L_{10} x T_1 was good performer under rainfed and irrigated.

Combining ability effects

The negative GCA effects for parental lines L_1 and L_8 under rainfed; L_3, L_6 and L_7 under irrigated and L_3, L_6 and L_2 under terminal drought, revealed their good general combining ability for earliness (days to pollen shad, silking

Table 1. Analysis of variance for seven traits in maize

Source	d.f.	Env.	Mean Sum of Squares						
			Days to 50% pollen shad	Days to 50% silking	Days to 50% maturity	Anthesis-silking interval (days)	Plant height (cm)	Ear height (cm)	Grain yield/ plant (2)
Analysis of Variance for Indidual Environment									
Replication	2	E1	7.80**	7.04**	1.32	0.01	351.72**	44.58	15.11
		E2	8.64**	9.61**	0.20	0.03	10.07	9.61	167.61**
		E3	7.78**	6.87**	7.73**	4.47**	0.35	0.41	2.60
Genotype	34	E1	7.95**	9.39**	2.78**	0.29	892.55**	389.23**	544.77**
		E2	26.47**	37.66**	6.62**	3.25**	814.96**	521.01**	6180.98**
		E3	50.70**	61.55**	13.83**	9.84**	1468.98**	574.59**	1429.52**
Error	68	E1	0.99	1.09	0.82	0.24	29.50	29.31	12.38
		E2	0.76	0.85	0.88	0.60	19.16	9.54	33.82
		E3	1.14	0.80	1.08	0.58	3.73	1.46	2.88
Pooled Analysis of Variance									
Environment	2	-	88356.0**	94385.0**	123620.0**	193.9**	186330.0**	27091.0**	191130.0**
Rep.! env.	6	-	8.07**	7.84**	3.08**	1.50**	120.71**	18.20**	61.78**
Genotype	34	-	50.82**	63.50**	11.86**	5.33**	2131.10**	801.47**	4284.50**
GxE	68	-	17.15**	22.55**	5.68**	4.03**	522.69**	341.68**	1935.40**
Pooled Error	204	-	0.96	0.91	0.93	0.47	17.46	13.44	16.36
Analysis of Variance for Combining ability									
GCA	11	-	0.085	0.049	0.022	0.001	3.563	1.762	-0.613
SCA	19	-	1.205	0.791	0.255	-0.078	-23.676	-4.338	-35.469
ifg	-	-	0.169	0.097	0.043	0.001	7.126	3.524	-1.226
if.	-	-	1.215	0.789	0.254	-0.072	-23.574	-4.228	-35.674
ifg/if.	-	-	0.139	0.123	0.169	-0.014	-0.302	-0.833	0.034

*,** Significant at 5% & 1% level, respectively

Table 2. Superior parental lines and hybrids identified on the basis of *per se* performance under various environments for seven traits in maize

Parental line			Hybrid		
Rain fed *kharif* 2004	irrigated *rabi* 2004-05	Terminal drought *rabi* 2004-05	Rain fed *khar:f* 2004	irrigated *rabi* 2004-05	Terminal drought *rabi* 2004-05
Days to 50% pollen shad					
Tz (47.67)	Ls (93.67)	L1 (98.00)	L3 x Tz (46.00)	L3x T, (93.67)	L3 x Tz (93.00)
L, (48.67)	L6 (95.00)	LIO (100.00)	Lg X Tz (46.33)	Lgx Tz (94.00)	Lsx T, (94.00)
Lg (48.67)	L3 (96.67)	Lz (100.00)	L7x Tz (47.33)	L7x Tz (94.33)	L6x T, (95.00)
Lz (49.33)	LIO (98.33)	L3 (100.00)	L, X Tz (47.67)	L3x Tz (94.33)	Lgx Tz (95.00)
T) (49.67)	Lz (99.67)	Ls (100.33)	Lsx T1 (47.67)	L7x T, (94.33)	L7 x T z (96.00)
Mean (50.11)	Mean (98.69)	Mean (102.50)	Mean (48.30)	Mean (96.70)	Mean (99.17)
Davs to 50% silking					
Tz (49.33)	Ls (96.00)	L1 (102.00)	L3x Tz (48.33)	L7xTI (95.67)	L3x Tz (97.33)
L1 (50.67)	L6 (98.33)	L3 (103.00)	Lgx Tz (48.33)	L6xTI (96.67)	Lsx T, (98.00)
Lg (51.00)	L3 (98.67)	Ls (103.00)	L, x Tz (49.33)	L3 x Tz (97.00)	L6x Tz (100.33)
Lz (51.67)	L1 (100.00)	L9 (104.33)	Lgx T, (49.33)	L6xTz (97.00)	Lgx Tz (101.33)
Ls (52.00)	LIO (100.33)	LIO (105.00)	Lsx T1 (49.67)	Lgx Tz (97.00)	L,xTz (101.33)
Mean (52.33)	Mean (101.61)	Mean (106.81)	Mean (50.25)	Mean (99.00)	Mean (103.93)
Davs to 50% maturity					
L3 (77.67)	L7 (137.00)	L, (132.00)	L4 x T1 (77.00)	L7x Tz (138.00)	L1xT, (131.33)
Tz (78.32)	L, (137.67)	L3 (134.33)	L3x T, (77.67)	L6x T, (138.67)	L3 x Tz (132.67)
Ls (78.67)	L4 (138.33)	L7 (134.67)	Lsx T, (77.67)	L7x T, (138.67)	LgxTz (133.33)
LIO (78.67)	Ls (138.33)	Ls (135.00)	L6x T1 (77.67)	L, x Tz (139.00)	L, x Tz (133.67)
L, (79.00)	Lg (139.33)	LIO (135.00)	L4 x Tz (77.67)	L3x Tz (139.00)	L6x Tz (133.67)
Mean (79.25)	Mean (139.61)	Mean (135.75)	Mean (78.30)	Mean (140.35)	Mean (135.78)
Anthesis-silking interval (days)					
Tz (1.67)	L1 (1.67)	L6 (2.33)	L, x T, (1.67)	L9x Tz (1.33)	L,x T, (2.67)
L4 (1.67)	L3 (2.00)	L3 (3.00)	L6x T1 (1.67)	L7x T, (1.33)	L, x Tz (2.67)
L, (2.00)	L4 (2.00)	L4 (3.00)	L9x T, (1.67)	Lzx T, (1.33)	L3x T, (3.00)
L3 (2.00)	LIO (2.00)	Ls (3.00)	L1 x Tz (1.67)	Lsx T. (1.67)	Lsx Tz (3.33)
LIO (2.33)	Ls (2.33)	L9 (3.33)	L4xTz (1.67)	L6x T, (1.67)	L6x Tz (3.33)
Mean (2.22)	Mean (2.81)	Mean (4.36)	Mean (1.98)	Mean (2.32)	Mean (4.75)
Plant height (cm)					
L4 (233.33)	L4 (171.67)	T1 (150.00)	L9x T, (248.33)	L9xT, (179.00)	Lsx T, (188.67)
L3 (225.00)	L((168.33)	L4 (146.67)	LIOx T1 (248.33)	LIOx T1 (185.00)	L4x T, (160.00)
L6 (220.00)	T((168.33)	L1 (125.00)	L, x Tz (243.33)	L,xT1 (185.00)	L, x T, (157.67)
Ls (219.00)	Ls (154.33)	L7 (122.00)	Ls x Tz (238.33)	Lg x T, (176.67)	LzxT, (155.33)
Tz (216.67)	Tz (151.67)	Lz (121.00)	Lzx T, (233.33)	L4 x T1 (175.00)	LIOx T, (153.33)
Mean (209.22)	Mean (151.33)	Mean (I 18.92)	Mean (224.88)	Mean (165.00)	Mean (147.20)
Ear height (cm)					
T, (76.67)	Lg (51.67)	Lg (41.00)	L3x T, (74.33)	L9x Tz (61.67)	L6xT, (50.33)
LIO (76.67)	L7 (58.33)	L9 (44.67)	L9x Tz (80.67)	LIO Tz (65.00)	L7x T, (51.00)
L3 (85.00)	L6 (60.00)	L6 (45.67)	L, x T1 (86.67)	L7x Tz (65.67)	L7x Tz (52.67)
Lz (85.33)	L9 (66.67)	L7 (45.67)	L3x Tz (86.67)	L7x T, (66.67)	Lgx T, (53.67)
L9 (90.00)	Ls (68.33)	Ls (51.00)	L4x Tz (86.67)	L4x Tz (93.33)	L9xT, (53.67)
Mean (91.06)	Mean (72.22)	Mean (55.3 I)	Mean (98.52)	Mean (80.20)	Mean (67.20)
Grain yield per plant (g)					
Tz (81.33)	Tz (156.33)	L, (93.67)	LzxT, (105.00)	L4x T, (248.33)	L,x Tz (121.67)
T) (78.33)	T, (153.67)	T1 (93.00)	Ls x Tz (89.33)	Lg x T, (232.33)	L3x T, (120.00)
L1 (75.33)	Ls (132.67)	Lz (90.33)	L6 x Tz (88.33)	LIO x T, (206.00)	Lsx T, (102.00)
Lz (74.00)	L6 (127.33)	Tz (83.00)	L9x Tz (86.67)	L4 x Tz (202.33)	L6x T, (101.67)
L4 (72.67)	L) (120.00)	Ls (68.00)	LIOx TZ (83.00)	L9xT1 (201.00)	Ls x Tz (99.67)
Mean (65.89)	Mean (106.78)	Mean (62.97)	Mean (77.43)	Mean (175.97)	Mean (80.47)

and maturity) (Table 3). Similarly, negative SCA effects for hybrids L_5 x T_1 under rainfed; L_9 x T_1 and L_8 x T_2 under irrigated, while L_4 x T_1 and L_9 x T_1 under terminal moisture stress indicated superiority of hybrids for earliness. Inbreds L_1 and L_9 exhibited negative GCA effects for ASI under varying environments and hybrid L_2 x T_1 showed negative SCA effects under rainfed and irrigated, while hybrid L_7 x T_1 under irrigated and moisture stress conditions for narrow ASI.

Table 3. Superior parental lines and hybrids identified on the basis of combining ability under various environments for seven traits in maize

GCA effects			SCA effects		
Rain fed *kharif* 2004	irrigated *rabi* 2004-05	Terminal drought *rabi* 2004-05	Rain fed *kharif* 2004	irrigated *rabi* 2004-05	Terminal drought *rabi* 2004-05
Days to 50% pollen shad					
Lg (-1.13**)	L3 (-2.70**)	Ls (-3.17**)	L3 x T2 (-1.17)	L9x T] (-1.13)	L4x T) (-4.63**)
L3 (-0.80)	L7 (-2.37**)	L6 (-3.17**)	Lsx T) (-0.83)	Lgx T2 (-1.03)	L9x T) (-4.47**)
L7 (-0.47)	L6 (-1.70**)	L3 (-2.67**)	L4x T] (-0.67)	L4x T2 (-0.70)	L7x T2 (-4.37**)
T2 (-0.33)	Lg (-1.37**)	Lg (-0.50)	L9x T) (-0.50)	L3 x T) (-0.63)	Lg x T2 (-3.37**)
L) (-0.13)	L4 (-0.70)	T2 (-0.30)	Lgx T2 (-0.50)	LIOx T2 (-0.50)	L3 x T2 (-3.20**)
Days to 50% silking					
Lg (-1.42**)	L7 (-2.50**)	Ls (-4.27**)	L3xT2 (-1.03)	Lgx T2 (-1.30)	L4x T, (-5.70**)
L) (-0.75)	L6 (-2.17**)	L3 (-3.93**)	LsxTI (-0.75)	L7x T) (-1.03)	L9x T) (-4.53**)
L3 (-0.58)	L3 (-1.50**)	L6 (-2.60**)	L2x T) (-0.42)	L2x T1 (-0.87)	L7x T2 (-3.30**)
T2 (-0.25)	L4 (-1.00*)	L) (-1.93**)	L9x TJ (-0.42)	L4x T2 (-0.80)	Lg x T2 (-2.63**)
Ls (-0.08)	Ls (-0.50)	T2 (-0.20)	L7xT2 (-0.42)	L9x T) (-0.53)	L3 x T2 (-2.47**)
Days to 50% maturity					
L4 (-0.97)	L7 (-2.02**)	L] (-3.28**)	L6 x T) (-0.53)	L6x T) (-1.52*)	L4x T1 (-2.75**)
L7 (-0.47)	L3 (-1.18**)	L6 (-1.45**)	Lgx T2 (-0.47)	L2x T2 (-0.98)	L9x T, (-1.92*)
Lg (-0.30)	L6 (-0.52)	L3 (-0.95*)	Ls x T] (-0.37)	Lgx T2 (-0.82)	L3x T2 (-1.75*)
L1 (-0.13)	L1 (-0.35)	Lg (-0.62)	L) x T2 (-0.30)	Lsx T) (-0.68)	L)xT) (-1.58*)
T] (-0.13)	T2 (-0.35)	T2 (-0.42)	L3 x T) (-0.20)	L9x T, (-0.68)	L7 x T2 (-1.58*)
Anthesis-silking interval (days)					
L] (-0.32)	Ls (-0.65)	L1 (-2.08**)	L4x T2 (-0.22)	L2x T, (-1.05)	L6 x T2 (-2.05**)
L4 (-0.15)	L6 (-0.48)	L3 (-1.08**)	L2x T1 (-0.12)	L3x T2 (-0.95)	L7x T) (-1.12)
L6 (-0.15)	L9 (-0.48)	Ls (-1.08**)	L3xT) (-0.12)	L7x T1 (-0.72)	L,ox T2 (-1.05)
L9 (-0.15)	L4 (-0.32)	L9 (-0.58)	L6xTJ (-0.12)	L9xT2 (-0.62)	L4xT) (-0.95)
T1 (-0.05)	L1 (-0.15)	L2 (-0.42)	L9x T) (-0.12)	Lg x T2 (-0.28)	Lgx T) (-0.78)
Plant height (cm)					
Ls (15.12**)	Lg (10.83**)	Ls (22.63**)	L) x T2 (18.02**)	L9x T, (24.83**)	Lsx T) (13.83**)
LIO (10.95**)	L) (9.67**)	L4 (7.13**)	L9x T) (14.15**)	Lsx T2 (14.00**)	L3x T1 (13.00**)
L9 (5.62*)	LIO (9.17**)	T) (5.00**)	LIOx T) (8.82*)	L3.x T2 (7.33*)	L7x T2 (12.33**)
L2 (4.28)	TJ (6.50**)	L2 (4.97**)	L6x T) (4.65)	L6x T2 (6.50*)	L9x T2 (8.67**)
L) (4.12)	L4 (0.00)	Lg (4.47**)	L3 x T2 (4.52)	Lgx T2 (5.67)	L6 x T2 (5.67**)
Ear height (cm)					
L3 (-18.02**)	L7 (-14.03**)	L7 (-15.37**)	L9x T2 (-14.72**)	L9x T2 (-16.70**)	L1 x T2 (-14.57**)
L4 (-7.68**)	L3 (-9.70**)	L6 (-15.03**)	L)xTJ (-11.28**)	Lsx T) (-12.47**)	Lgx T, (-12.43**)
Lg (-7.68**)	L6 (-5.20**)	L3 (-9.87**)	L7x T] (-6.28)	L) x T2 (-10.87**)	L9x T) (-7.60**)
L9 (-3.52)	LIO (-5.20**)	L9 (-5.70**)	L3xT] (-5.78)	L4x T1 (-9.13**)	L2 x T2 (-5.90**)
T] (-0.38)	T2 (-3.30**)	Lg (0.87**)	L4x T2 (-4.55)	L)ox T2 (-6.70**)	L4 x T2 (-3.07**)
Grain yield per plant (g)					
L2 (7.07**)	L4 (49.37**)	L3 (21.87**)	L2xTJ (21.27**)	Lgx T) (23.57**)	L) x T2(24.93**)
L9 (3.07*)	Lg (25.87**)	Ls (20.37**)	L6 x T2 (10.57**)	L2x T2 (23.43**)	L3x T) (14.73**)
L) (2.23)	LIO (15.20**)	LJ (19.20**)	Ls x T2 (9.23**)	L3 x T2 (18.60**)	L2x T, (8.07**)
Ls (1.90)	L9 (7.53**)	L6 (11.53**)	L7 x T2 (6.90*)	L4x T) (16.07**)	L9x T, (8.07**)
T2 (0.77)	T2 (6.93**)	Lg (7.37**)	LIOxT) (6.60*)	L)x T2 (13.77**)	L7 x T2 (7.60**)

The positive GCA effects for plant height were observed for inbreds L_5 and L_5 under rainfed and terminal drought, while L_1 under rainfed and irrigated situations indicated their good general combining ability for more plant height. Hybrids L_9 x T_1, and L_3 x T_2 found better under rainfed and irrigated, while L_6 x T_2 under irrigated and moisture stress conditions as they possessed positive SCA effects for the trait. The negative GCA effects for ear height were recorded for inbred L_3 under varying environments, while negative SCA effects for hybrid L_9 x T_2 under rainfed and irrigated; L_1 x T_2 under irrigated and terminal moisture stress and L_4 x T_2 under rainfed and terminal drought, suggested low cob placement under varying environments. Grain yield per plant was highly influenced by environmental changes. The good general combining ability recorded for parental lines L_9 and T_2 under rainfed and irrigated; L_1, and L_5 water stress (rain fed and terminal drought) situations, while L_8 under irrigated and terminal moisture stress as they exhibited positive GCA effects. Hybrids L_2 x T_1 and L_7 x T_2 showed positive SCA effects under rainfed and moisture stress conditions revealed that these hybrids shall perform better under terminal drought prone areas. Hybrid L_9 x T_2 exhibited positive SCA effects under irrigated and terminal moisture stress indicated that it would perform better in *rabi* season. Yadav *et al.* (2003) and Betron *et al.* (2003) also identified good general combiners and superior hybrids for various yield-contributing traits at different levels of moisture stress.

Heterobeltiosis and economic heterosis

The superiority of hybrids L_3 x T_z 'and L_8 x T_2 was observed for early flowering over better parent and standard check under moisture stress (i.e. rain fed and terminal drought) (Table 4). Hybrids L_4 x T_2, L_7 X T_2 and L_9 x T_2 showed early flowering under irrigated conditions over better parents. The early maturing hybrids L_4 x T_1 and L_8 x T_2 exhibited superiority over parental lines under rainfed and terminal drought, while hybrid L_4 x T_1 found better for rainfed and L_1 x T_1 for terminal moisture stress over standard check. A narrow range of anthesis-silking interval over better parents was observed for hybrids L_1 x T_1 and L_2 x T_1 under rainfed and terminal drought; L_6 x T_1 for rainfed and irrigated situations, while L_2 x T_1 and L_7 x T_1 under irrigated and terminal moisture stress. Plant height found superior over better parent and standard checks for hybrids L_9 x T_1 and L_{10} x T_1 in rainfed; hybrids L_5 x T_2 and L_8 x T_2 exhibited more plant height over better parents under irrigated and terminal moisture stress. Hybrid L_3 x T_1 exhibited low cob placement over better parent under varying environments, while over standard check under rainfed. The higher grain yield per plant over better parental lines and standard checks were recorded for hybrids L_2 x T_1, L_5 X T_2, L_6 X T_2, L_9 X T_2 and L_{10} x T_1 under rainfed; L_4 x T_1, L_6 X T_1, L_9 X T_1 and L_{10} x T_1 under irrigated and L_3 x T_1, L_5 x T_1, L_6 X T_1, L_1 X T_2 and L_5 x T_2 under terminal moisture stress. Yadav *et al.* (2003) and Betron *et al.* (2003) also selected early maturing, superior hybrids for grain yield and its attributes under different moisture stress environments.

Thus, overall estimates of various parameters indicated that parental lines l1 (i.e.EI-569) in rainfed; L4 (i.e.EI-572) in irrigated and L1 (i.e. EI-569) and Ls (i.e. EI-573) in terminal drought environments exhibited good general combining ability along with high per se performance for earliness, grain yield and its various contributing traits. These inbred lines shall be used in various maize breeding programmes for drought tolerance. Hybrids L_2 x T_1 (i.e. EI-570 x CML-341), L_5 x T_2 (i.e. EI-573 x Pool 16 BN), L_6 x T_2 (i.e. EI-574 x Pool 16 BN) and LIO x T_1 (i.e. EI-578 x CML-341) under rainfed; L_4 x T_1 (i.e. EI-572 x CML-341) and L_5 x T_1 (i.e. EI-576 x CML-341) under irrigated and L3 x T_1 (i.e. EI-571 x CML-341) and L_1 x T_2 (i.e. EI-569 x Pool 16 BN) under moisture stress conditions found superior, since these hybrids showed higher estimates of per se performance, SCA effects, heterobeltiosis and economic heterosis for grain yield and its various attributes, suggested their suitability under respective environments. These hybrids shall be further evaluated in multilocation yield trials.

Table 4. Superior hybrids identified on the basis of heterobeltiosis and economic heterosis under various environments for seven traits in maize

Heterobeltious			Economic heterosis		
Rain fed *kharif* 2004	irrigated *rabi* 2004-05	Terminal drought *rabi* 2004-05	Rain fed *kharif* 2004	irrigated *rabi* 2004-05	Terminal drought *rabi* 2004-05
		Days to 50% pollen shad			
Lsx T1 (-4.03*)	L7x T, (-6.60**)	L6 x Tz (-7.62**)	L3xTz (-3.50*)	-	L3x Tz(-5.10**)
Lzx Tz (-3.50*)	Lsx Tz (-5.05**)	L3x Tz (-7.00**)	Lsx Tz (-2.80)	-	Ls x T I (-4.08**)
L4x Tj (-3.36*)	L7xTz (-4.71**)	L7x Tz (-6.80**)	L7x Tz (-0.70)	-	L6 x T1 (-3.06**)
Lsx Tz (-2.80)	L4x Tz (-4.04**)	Ls x Tz (-5.56**)	Lsx T1 (-0.01)	-	LsxTz(-3.06**)
L7 x T) (-2.68)	Ls x T) (-3.97**)	LsxT) (-6.31**)	L, x Tz (-0.01)	-	L7x Tz(-2.04*)
		Days to 50% silking			
Lsx T1 (-4.03*)	L7x T, (-6.60**)	L6 x Tz (-7.62**)	L3xTz (-3.50*)	-	L3x Tz(-5.10**)
Lzx Tz (-3.50*)	Lsx Tz (-5.05**)	L3x Tz (-7.00**)	Lsx Tz (-2.80)	-	Ls x T I (-4.08**)
L4x Tj (-3.36*)	L7xTz (-4.71**)	L7x Tz (-6.80**)	L7x Tz (-0.70)	-	L6 x T1 (-3.06**)
Lsx Tz (-2.80)	L4x Tz (-4.04**)	Ls x Tz (-5.56**)	Lsx T1 (-0.01)	-	LsxTz(-3.06**)
L7 x T) (-2.68)	Ls x T) (-3.97**)	LsxT) (-6.31**)	L, x Tz (-0.01)	-	L7x Tz(-2.04*
		Days to 50% maturity			
L4x T1 (-2.53**)	Lgx T1 (-1.17*)	Lsx Tz (-2.44**)	L4x T1 (-0.86)	-	L1xT, (-0.51)
Lsx T1 (-1.69**)	L6 x T1 (-0.95)	Lgx T, (-1.70**)	-	-	-
L6x T, (-1.27)	L3 x Tz (-0.48)	L3 x Tz (-1.24)	-	-	-
L4 X Tz (-0.85)	L3 x T1 (-0.24)	L6x Tz (-0.99)	-	-	-
Lsx Tz (-0.85)	-	L4 x T1 (-0.98)	-	-	-
		Anthesis-silking interval (days)			
L6x T) (-28.57)	L7 x T j (-66.67* *)	Lj x T1 (-33.33*)	-	-	-
Lg X Tj (-28.57)	Lzx T1 (-60.00**)	L1 x Tz (-33.33*)	-	-	-
L) X T1 (-16.67)	Lgx Tz (-55.56*)	L7 x T) (-8.33)	-	-	-
Lzx T, (-14.29)	L6 x T) (-50.00*)	Lzx T1 (-7.14)	-	-	-
Lsx T1 (-14.29)	L6 x Tz (-33.33*)	Lzx Tz (-0.01)	-	-	-
		Plant height (cm)			
LlOx T) (30.70**)	Lsx Tz (15.38**)	Ls x Tz (31.23**)	LgxT, (0.01)	-	-
LgxT, (20.16**)	Lgx T, (12.87**)	Ls x Tz (26.89**)	LlOx T, (0.01)	-	-
L7x T1 (20.00**)	Lsx Tz (10.15**)	Lsx T1 (25.78**)	-	-	-
L,xTz (12.31**)	L)xTI (9.90**)	Lzx Tz (23.14**)	-	-	-
L6x T1 (5.76**)	LIO x T) (9.90**)	L6x Tz (22.92**)	-	-	-
		Ear height (cm)			
Lgx Tz (-10.37*)	Lgx Tz (-7.50*)	L3xT,(-6.78)	L3x T1 (-3.04)	-	-
L4x Tz (-5.45)	LlOx T, (-7.27*)	-	-	-	-
Lsx Tz (-3.64)	LlOx Tz (-4.88)	-	-	-	-
L3 X T, (-3.04)	L3 x T1 (-3.26)	-	-	-	-
-		-	-	-	-
		Grain yield per plant (g)			
Lzx T1 (37.86**)	L4x T) (61.61 **)	L, x Tz (29.89**)	Lzx T1 (29.10**)	L4x T, (58.85**)	L1 xTz (29.89**)
Ls x Tz (9.84**)	LsxTI (51.19**)	L3 x T) (29.03**)	Ls x Tz (9.84**)	LsxT1(48.61**)	L3 xTI (28.11 **)
L6xTz(8.61*)	LlOx T) (34.06**)	Ls x Tz (20.08**)	L6xTz(8.61*)	LIO x Tj (31.77**)	Lj xT, (8.90**)
LgxTz (6.56)	Lg x T) (30.80**)	Ls x T1 (9.68**)	Lgx Tz (6.56)	Lg x T, (28.57**)	L6xTI (8.54**)
LlOx T, (5.96)	L4x Tz (29.42**)	L6x T) (9.32**)	LIO x Tj (2.05)	Lzx Tz (15.35**)	LjxT2(6.41**)

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MICRONUTRIENT MANAGEMENT THROUGH NITROGEN FORTIFIED CROP RESIDUE COMPOST UNDER WHEAT (*TRITICUM AESTIVUM*)

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ABSTRACT

Field experiments were conducted at IAR! farm for four *rabi* season in the years 2000-01 to 2003-04 to study the influence of nitrogen fortified crop residue compost on the grain and straw yield and total uptake of micronutrients *viz.*, Zn, Cu, Mn and Fe by wheat and their available status in soil at harvest. Nitrogen was supplied @ 120 kg/ha from N-fortified crop residue compost or urea or both in combinations in three ratios 4:1, 3:2 and 1:1. The grain yield in various N treatments increased from 45.6 to 106.1 per cent over control during the four years. The maximum grain yield (44.9 to 60.8 q/ha) was noticed with the combined application of N through fortified compost and urea in 1:1 ratio in all the four years. Among all the N treatments, 1: 1 ratio had maximum total uptake of micro nutrients which showed an increase from 21.8 to 33.3 % for Cu, 23.0 to 27.9 % for Zn, 5.2 to 10.7 % for Fe and 2.3 to 10.5 % for Mn over the treatment where N was applied through urea alone in all four years of experimentation. The treatments comprised of compost alone and its combinations with urea i.e. 4:1 and 3:2 were intermediate in effect in relation to grain yield and uptake of micronutrients. Moreover, increasing proportion of N through compost from 50 to 100% resulted in proportionate increase in the build up of available micronutrients in soil.

Key words : Wheat, fortified compost, grain yield, micronutrient uptake.

Intensive cultivation, growing of exhaustive crops, imbalanced use of fertilizers and inadequate and irregular application of manures haye made the soil deficient or marginal in macro as well as micronutrients, hence crops need their regular application in soils. Manures are known to supply both macro and micronutrients to crops, in addition to increase their use efficiency from the native soil source. Although the requirement of micronutrients are very low but their effects on crop yield are very significant. The use of organics in nutrient management can sustain balanced supply of nutrients, (Dangarwala, 2001). It is well known that manures not only supply the plant nutrients but also improve the soil health. Keeping these facts in view, field experiments were conducted for four years at IARI research farm to study the effect of N-fortified crop residue compost and urea on the management of micronutrients in wheat crop.

MATERIALS AND METHODS

Field experiments were conducted at IARI Farm, New Delhi during the four *rabi* seasons in the years 2000-2004 with wheat as test crop using nitrogen fortified crop residue compost as source of micronutrients. Nitrogen fortified crop residue compost was prepared from chopped dried paddy straw enriched with urea nitrogen. The proportion of nitrogen added through urea (2 kg N) was approximately three times the nitrogen contained in 100 kg dried straw. For faster decomposition of paddy straw, cow dung slurry was sprayed over the composting material and sufficient moisture was maintained for compo sting under anaerobic condition. Mature composted products were analyzed for total N, P, K and micronutrients (Zn, Cu, Mn and Fe) using standard procedures (Jackson, 1973). The nutrients composition of compost products during four years ranged from 3.10 to 3.29% for total N; 0.58 to 0.77 % for P; 2.04 to 2.49% for K;

63 to 67 µg/g for Zn; 21 to 33 µg/g for Cu; 337 to 543 µg/g for Mn and 709 to 801 µg/g for Fe. The nitrogen was added @ 120 kg/ha under N treatments which comprised of control (T_0); 100 % N through fortified crop residue compost alone (T_1); 80 % N through fortified compost + 20 % N through urea i.e. 4:1 (T_2); 60 % N through fortified compost + 40 % N through urea i.e. 3:2 (T_3); 50 % N through fortified compost + 50 % N through urea i.e. 1:1 (T_4) and 100 % N through urea alone (T_5). Fortified compost was applied in the field one week before sowing the crop. The basal doses of P and K were applied @ 60 kg P_2O_5 and K_2O each/ha in each treatment except control through singlesuperphosphate and murate of potash respectively. The wheat CV:2687 was sown in 8X5 m^2 plots after incorporation of compost and fertilizer. The treatments were replicated thrice. After harvesting the crop, grain and straw yields were recorded plot wise and grain, straw and soil samples were collected for analysis. Dried samples of grain and straw were digested in tri acid mixture (HNO_3, H_2SO_4 and $HClO_4$) and Zn, Cu, Mn and Fe contents were estimated in the acid digest using atomic absorption spectrometer. The soil samples collected at the start of the experiment as well as post harvest were analyzed for available Zn, Cu, Mn and Fe in diethylene triamine penta acetic acid (DTP A) extract (Lindsay and Norvell, 1978).

The main characteristics of soil of the experimental site were as: sandy clay loam in texture with pH, 7.9; EC, 0.37 dSm-1; organic carbon, 5.1 g/kg; available N, P and K, 179, 22.6 and 236 kg/ha, respectively. The available contents of micronutrients, viz. Zn, Cu, Mn and Fe were 1.02, 0.93, 10.4 and 5.1 mg/kg, respectively. The experiments were laid out in a randomized block design and the statistical analyses was carried out according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Grain and straw yield

Data on grain and straw yield of wheat shown in Table 1 clearly indicated that nitrogen @ 120 kg/ha whether applied through fortified compost material alone (T_1) or urea alone (T_5) or their different combinations in various ratios i.e. 4:1, 3:2 and 1:1 (T_2, T_3 and T_4) produced significantly higher grain yield over control which ranged from 38.3 to 60.8 q/ha in various N treatments as against 26.3 to 29.3 q/ha in control during the four years of experiment. Application of 50 % N through fortified compost material plus 50 % N through urea (T_4) produced highest grain yield of wheat ranging from 44.9 to 60.8 q/ha which was significantly greater over other treatments in all the years of experimentation except the first year (2001). Addition of N, 60 % through fortified compost material plus 40% through urea (T_3) or 100 % N through urea alone (T_5) both were at par in relation to grain yield of wheat in the first three years (2001, 2002 and 2003). However, 100% N applied through urea (T_5) was significantly higher over other treatments (T_0, T_1 and T_2) in this respect except the third year where T_5 and T_2 were comparable with respect to grain yield. The magnitude of increase in grain yield in various N treatments varied from 45.63 to 106.10 % over control. The straw yield of wheat followed the trend similar to grain yield except the year 2003 where straw yield showed the reverse trend with grain yield. In general, the straw yield in N treatments was maximum in T_4 followed by $T_5 > T_3 > T_2 > T_1$.

The N- fortified composted crop residue is a slow release material and nutrients from compost are released only upon mineralization. The highest grain yield response in T_4 treatment (50 % N through fortified compost plus 50 % N through urea) can be attributed to the release and availability of nutrients to the crop through out the growth period. The readily available half dose of N applied through urea met the requirement of crop at the initial stages of growth and the proportion of N applied through organic source took care the requirement of the crop at later stages of growth. In this way, possibly, 50% N from readily available plus 50% N from slow release compost suitably matched the requirement of N and other nutrients as well through out the crop growth period which resulted in the highest grain yield over other N treatments. Takkar (1996) and Nayyar (1999)

Table 1. Effect of nitrogen supply from N- fortified compost and fertilizer on grain and straw yield of wheat during 200-01 to 2003-04

Treatment	2000-01		2001-02		2002-03		2003-04	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_0	26.3	46.8	25.8	52.5	29.5	49.0	25.5	32.6
T_1	38.3	74.2	41.7	61.8	33.0	51.3	28.3	35.8
T_2	40.4	80.7	45.0	64.5	44.3	51.3	32.8	42.6
T_3	42.3	80.6	51.3	65.5	46.3	43.5	39.9	51.7
T_4	44.9	82.3	60.8	73.3	51.5	41.4	51.3	63.8
T_5	42.5	80.2	50.5	67.3	43.5	46.5	45.3	56.8
CD (P=0.05)	2.82	5.46	3.30	4.71	2.94	3.36	2.67	3.39

T_0 = Control; T_1 = 100% N through fortified compost, T_2 = 80% N through fortified compost + 20% N through urea; T_3 = 60% N through fortified compost + 40% N through urea; T_4 = 50% N through fortified compost + 50% N through urea; T_5 = 100% N through urea.

noted that use of organic manures helped in correcting micronutrients deficiencies and sustaining high productivity. In other combinations where N proportion from organic source was more than 50%, very possibly the rate of N and other nutrients release from them might have not matched the requirement of crop at peak growth period. consequently, the grain yield in these treatments was lower than T_4.

Uptake of zinc, copper, mangenese and iron

The uptake of various micronutrients in grain was m decreasing order in all the four years as Fe>Mn>Zn>Cu -irrespective of the treatments. Among the treatments, T_4 i.e. 50% N supplied from fortified compost + 50% N through urea brought about maximum uptake of micronutrients in wheat grain invariably in all the four years of field experiments. The figure further showed that total N requirement of wheat whether fulfilled through urea alone or from combination of 60% N through fortified compost plus 40% N through urea both were comparable in relation to uptake of micronutrients in wheat grain during the four years which were followed by T_2 (80% N through fortified compost + 20% N through urea) and T_1 (100% N through fortified compost). The uptake of micronutrients in control treatment was significantly lower than the various N treatments in all the years.

The critical appraisal of the data on total uptake of micronutrients by wheat shown in table 2 revealed that the total uptake of various micronutrients was in decreasing order as Mn>Fe>Zn>Cu invariably in all the treatments through out the four years. Among the treatments, T_4 had highest total uptake of micronutrients, which varied from 2445.1 to 5121.4 g ha-1 for Mn, 1790.8 to 2986.1 g/ha for Fe, 447.1 to 702.5 g/ha for Zn and 149.0 to 213.3 g/ha for Cuover the four years of field experiments. Application of N either as urea alone (T_5) or 60% N through fortified compost plus 40% N through urea (T_3), both were equivalent in effect in relation to uptake of micronutrients ex'tept the year 2002 and 2004 where T_3 was significantly better than T_5 with respect to Zn and Cu, respectively. Both the treatments (T_3 and T_5) were comparable with respect to Mn and Fe in 2001 and 2003 or significantly lower than T_4 in relation to Zn and Cu in three years only. The micronutrient uptake in control was significantly lower than N treatments irrespective of the years. The extent of increase in the total uptake of various micronutrients by wheat due to T_4 (50% N through fortified compost + 50% N through urea) treatment over T_5 (100 % N through urea) ranged from 21.83 to 33.31% for Cu, 23.06 to 27.89% for Zn, 5.25 to 10.75% for Fe and 2.33 to 10.55% for Mn.

Table 2. Effect of nitrogen supply from N-fortified compost and fertilizer on total uptake of Zn, Cu, Mn and Fe in dry matter of wheat during 2001-2004

Treat-	2001				2002				2003				2004			
ments	Zn	Cu	Mn	Fe	Zn	Cu	Mn	Fe	Zn	Cu	Mn	Fe	Zn	Cu	Mn	Fe
T_0	214.0	64.5	1462.6	912.4	216.9	65.2	1574.2	952.0	208.4	61.2	1489.4	929.8	142.3	48.0	999.0	656.4
T_1	421.3	119.1	3226.1	2214.6	361.5	111.0	2483.7	1895.3	297.6	92.2	2055.1	1453.5	232.4	73.6	1616.3	1176.6
T_2	544.9	139.7	4281.7	2612.7	458.1	128.7	2926.4	2151.1	389.1	115.4	2391.1	1734.8	321.9	95.6	2201.2	1490.1
T_3	595.6	150.3	4601.4	2744.2	550.1	145.6	3272.7	2346.3	397.7	119.5	2288.1	1649.4	442.0	181.0	2809.2	1861.9
T_4	702.5	189.1	5121.4	2986.1	662.6	213.3	3780.2	2799.5	447.1	149.0	2445.1	1790.8	609.8	180.9	3787.4	2522.9
T_5	549.3	160.0	4632.8	2696.2	463.6	149.0	3277.0	2347.3	363.3	122.3	2389.3	1701.5	443.7	138.9	2931.1	1983.8
CD ($P=0.05$)	84.3	22.8	647.4	393.6	75.3	22.5	480.9	345.9	72.3	18.3	527.7	257.1	60.9	22.8	398.4	266.7

The highest uptake of micronutrients due to application of 50% N from fortified compost plus 50% N from urea can be ascribed to the fact that various low molecular weight organic acids such as succinic, citric, malic oxalilc and acetic acids are produced during the decomposition of compost in addition to the release of N and micronutrient cations. These organic acids form complexes with micronutrient cations and remain in soluble form by preventing micronutrients from precipitation, fixation, oxidation and leaching (Kumar *et al.*, 1993). The increased availability of micronutrients in addition to N to plants might have resulted in highest uptake of micronutrients in T_4 treatment, while rest of the treatments were not having the adequate proportion of N from both the sources, as a result, the availability of N and micronutrients upon decomposition of organic residue with urea could not match the requirement of crop as was the case with treatment T_4. Beelakki and Badanur (1997) observed that incorporation of organic source to meet 50% N in combination with 50% fertilizer N helped in maintaining higher DTP A extractable Zn, Cu, Mn and Fe in surface and subsurface soils. The highest removal of Zn, Cu, Mn and Fe by crops was observed under NPK + FYM treatment (Singh and Nand Ram, 2005).

Available status of micronutrients

Data on available status of micronutrients in soil after wheat presened in Table 3 clearly indicate that the status of various micronutrients in soil was significantly lower in control than the all N treatments during four years of field experiments. The data further showed that range values of available contents of all the four micronutrients were maximum in T_1 (100% N through fortified compost) followed by T_2 (80% N through fortified compost + 20% N through urea), T_3 (60% through fortified compost + 40% N through urea), T_4 (50% N through fortified compost + 50% N through urea) and T_5 (100% N through urea). Among the two sources of N applied in combination, the increasing proportion of fortified compost from 50% to 100% in T_4, T_3, T_2 and T_1 consistently and regularly increased the available contents of Zn, Cu, Mn and Fe in soil. In T_5 treatment (100% N through urea) had

Table 3. Effect of nitrogen supply from N-fortified compost and fertilizer on micronutrient status in soil after wheat (range during 2001 to 2004)

Treatment	Zn	Cu	Mn	Fe
T_0	1.40-1.50 (1.45)*	1.41-.44 (1.42)	8.10-8.80 (8.35)	4.51-4.82 (4.65)
T_1	1.84-1.88 (1.86)	1.52-1.56 (1.54)	8.60-9.10 (8.87)	4.86-5.62 (5.17)
T_2	1.68-1.75 (1.72)	1.48-1.54 (1.51)	8.52-9.24 (8.91)	4.68-5.76 (5.26)
T_3	1.62-1.72 (1.67)	1.48-1.54 (1.52)	8.42-9.02 (8.75)	4.48-5.70 (5.19)
T_4	1.56-1.70 (1.63)	1.46-1.53 (1.50)	8.56-9.24 (8.84)	4.44-5.56 (5.09)
T_5	1.44-1.52 (1.50)	1.45-1.49 (1.47)	8.26-8.80 (8.48)	4.26-5.04 (4.67)

*Figures in parenthesis are the average values.

lowest available contents of micro nutrients with mean values 1.50, 1.47, 8.48 and 4.67 µg/g for Zn, Cu, Mn and Fe, respectively, but marginally higher than control (To) with mean values 1.45, 1.42, 8.35 and 4.65 µg/g for Zn, Cu, Mn and Fe, respectively. Among all the treatments, the decreasing order of various micronutrients accordingly to their available range during four years was Mn, Fe, Zn and Cu.

The reason for the regular increase in available micronutrient content in soil as a result of increasing proportion of fortified compost in treatments (T_4, T_3, T_2 and T_1) may be attributed to the fact that compost upon mineralization ,released micronutrients in soil in amounts to its added proportion. Moreover, organic acids produced during decomposition of compost also enhanced the availability of micronutrients from soil (Fox and Commerford, 1990). Ismail *et al.* (2004) noted significant build up of Zn, Cu, Mn and Fe in soil in the treatment receiving 50% recommended dose of fertilizer plus 5 t FYM/ha under a long term field experiment on Vertisol.

On the basis of the uptake of micronutrients (Zn, Cu, Mn and Fe) by wheat under four years of field study the following conclusion may be drawn that N-fortified crop residue compost can serve a good source of micronutrients in addition to nitrogen. Among the various combinations of crop residue compost with urea, 50% N supplied from each source emerged out the best combination for the grain yield, availability and uptake of micronutrients point of view. The study also suggests that less th&. 50% replacement of fertilizer N through fortified crop residue compost is not beneficial from micronutrient management point of view.

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NITROGEN MANAGEMENT IN RAINFED DIRECT SEEDED UPLAND RICE (*ORYZA SATIVA*)

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ABSTRACT

A field experiment was conducted on rainfed direct seeded rice (*Oryza sativa* L.) during *kharif* season of 2003-04 to find out the effectiveness of different blending materials for pre-conditioning of urea at least 3 levels of N on grain yield, weed population and N status in plant and soil. Pre-conditioning of urea with farm yard manure (FYM) + soil (1 :3: 1) gave significantly higher grain yield and N accumulation in plant than that of prilled urea and soil mixed urea (1 :3). Preconditioning of urea with FYM + soil also recorded the maximum N contents throughout the crop growth period and soils . N status at harvest. Pre-conditioning of urea with rice husk + soil (1:3:1) and wheat husk + soil (1:3:1) were equally effective as pre-conditioning urea with FYM + soil in influencing grain yield, weed population and N accumulation of rice. The grain yield and N accumulation of rice increased significantly with the application of 80 Kg N/ha as compared to 60 and 40 kg N/ha.

Key words : Rainfed upland rice, prilled urea, pre-conditioned urea, weed population and N concentration.

Urea is a major nitrogenous fertilizers used for growing rice crop. But only 2030%of the applied N is utilized by the rice crop under upland rainfed condition Harsan.et al-(1992) reported a loss of 50% of the applied N within 2-3 weeks after its application in the field. Volatilization loss of N in the form of ammonia is the major cause of such low Nitrogen recovery under rainfed upland condition (Zian *et al*., 1992). Therefore it is need for identification of blending materials that can minimise N loss from urea and increase effectiveness of urea fertilizers and nitrogen use efficiency under rainfed upland situation. Hence an experiment was conducated on direct seeded rainfed upland rice to find out the effect of preconditioned urea and N Levels on grain yield, weed population and N status in plant and soil.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* season of 2003-04 at Regional Research and Technology transfer station OUAT, Chipilima, Orissa. The trial was laid out in factorial randomised block design with 3 replications. The soil was sandy loan in texture with pH 6.5, organic carbon 0.45% available N 220 kg, P_2O_5 16.6 kg, K_2O 225 kg/ha. The treatment consists of 3 levels of N (40, 60 and 80 kg/ha) and 5 forms of pre-conditioned urea such as , prilled urea,soil + saw dust mixed urea, (1:3:1), soil + rice husk mixed urea (1:3:1) , soil + Wheat husk mixed urea (1:3:1) soil + farm yard manure (FYM) mixed urea (1:3:1). For preconditioning first urea was thoroughly mixed with powder form of dry soil on equal basis. Then the soil urea mixture was added to each of the blending materials. Water was sprayed on the mixture for better sticking of those materials with urea granules. Then the mixture was kept under shade for 48 hrs. before application in the field. The N was applied into 3 splits Le. 25% at basal, 50% at maximum tillering stage and rest 25% at panicle initiation stage. An uniform dose of P_2O_5 (30 kg/ha) and K_2O (30 kg/ha) was applied to all the plots as basal through single super phosphate and muriate of potash. Vandana' was used as test variety by adopting row to row spcing of 20 cm and plant to plant continously. Nitrogen content in plant, grain and straw were analysed by micro-kjeldhal's method (Jackjon, 1970).

RESULTS AND DISCUSSION

Grain yield

Grain yield of rice of increased significantly with increasing level of N upto 90 kg/ha (Table 1). This was mainly due to significantly increase in all the yield attributing characters. Gupta and Sharma (1991) Rathore *et al.*, (1991) and Lakpale *et al.* (1991) also reported similar effect of N on grain yield of rice.

Application of pre-conditioned urea significantly increased the grain yield of rice under rainfed upland condition. pre-conditioning of urea with FYM + soil (1:3:1) and saw dust + soil (1:3:1) and wheat husk + soil (1:3:1) were found equally effective in influencing grain yield of rice. Application of pre-conditioned urea with soil + FYM (1:3:1) recorded the highest grain yield of rice due to slow and steady release of N resulting effective utilization under rainfed upland condition. The increase in grain yield over that of prilled urea was 15.62%. Mishra (1994) also reported that application of pre-conditioned urea with FYM was effective in increase the grain yield of rice and also increase the N use efficiency in rainfed upland rice.

Yield attributing characters

Effective tillers/m², spikelets/panicle, weight of panicle and 1000 grain weight increased significantly due to 90 kg N/ha. Application of 60 kg N/ha, insufficient to meet the intensity and capacity of soil to supply N to rice crop resulted in reduction of yield attributes as compared to 90 kg N/ha (Table 1).

Pre-conditioned urea with FYM + Soil (1:3:1) produced panicles/m², panicle weight and 1000 grain weight similar to that of pre-conditioned urea with wheat husk + soil (1:3:1). Pre-conditioned urea with FYM + soil (1:3:1) recorded significantly higher number of panicles /m², spikelets/panicle, panicle weight and 1000 grain weight with prilled urea. it is due to continuous supply of N to the plant for getting higher yield attributing characters. Lakpale *et al.* (1999) also reported similar effect of N on yield attributing characters of rice.

N content and uptake

Nitrogen concentration in plant was minimum at 30 days after showing and gradually reduced until maturity (Table 4) The nitrogen concentration of 30 DAS, 90 days and at harvest were significantly higher at 90 kg N/ha clearly indicating that application of 60 kg N/ha was insufficient to maintain the need of crop for getting higher yield (Table 4). The N accumulation in grain and straw was decreased with application of 60 kg N/ha. The N accumulation in grain and straw was decreased due to reduction of N concentration in plant and dry matter production under 60 kg N/ha.

Pre-conditioned of urea with FYM + soil (1:3:1) gave significantly higher N concentration and accumulation in plant than that of pre-conditioned urea with wheat husk + soil (1 :3:1) and prilled urea.

Application of pre-conditioned urea with FYM + soil (1 :3:1) maintained the N supply for longer period of the rice crop and increased N concentration and accumulation in plant. Shinde etal (1977) who reported similar results for use of straw as potential slow release nitrogen source for rice.

Pre-conditioned urea with rice husk + soil (1 :3:1) and pre-conditioned urea with wheat husk +soil (1:3:1) also produced similar nitrogen concentration in plant to that of pre-conditioned urea with FYM + soil (1:3:1). However, pre-conditioned of urea with saw dust + soil (1:3: 1) resulted in significant lower N concentration than pre-conditioned urea with FYM + soil.

Application of prilled urea reduced N concentration and accumulation in plant because it failed to meet the supply of N to rice plant due to greater N loss and resulted in poor N concentration and accumulation in plant and decreased grain yield of rice.

N status in soil

Available N content in soil after harvesting of rice increased (over native N in soil) with the application of N particularly during 2004, increased N uptake and the availability of native

Table 1. Growth and yield attributes of direct seeded rainfed upland rice as influenced by pre-conditioned urea and levels of N

Treatment	Plant height (cm)		LAI at Flowering		Panicle/m^2		Panicle length (cm)		Panicle weight (g)		Spikeletsl panicle		1000 grain weight (g)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
N (kg/ha)														
30	96	100	4.31	4.56	322	336	20.2	20.8	1.88	1.08	98	105	17.9	18.4
60	107	110	4.89	5.01	338	349	22.6	22.9	2.06	2.12	110	118	19.7	21.2
90	114	117	5.12	5.27	354	366	23.4	24.7	2.21	2.26	120	128	21.8	22.0
CD at 5%	5.61	6.78	4.18	3.76	8.02	10.12	0.11	0.16	0.09	0.13	5.69	8.34	0.12	0.17
Pre-conditioned	100	104	4.66	4.70	329	342	20.6	21.0	2.01	2.05	105	111	18.1	18.7
Urea														
Prilled urea														
Urea +saw dust + soil (1:3:1)	105	107	4.69	4.76	335	344	22.2	22.6	2.07	2.12	109	114	19.4	20.4
Urea +rice husk +soil 1:3:1)	110	113	4.73	4.90	3.39	350	22.4	22.8	2.15	2.19	116	119	20.7	21.5
Urea + wheat husk+soil 1 :3:1)	112	115	4.89	5.01	348	356	22.7	23.1	2.21	2.26	121	127	21.8	22.0
Urea + FYM + soil (1:3:1)	117	119	5.16	5.23	355	369	23.7	24.3	2.28	2.33	130	135	22.3	22.8
CD at 5%	6.7	4.9	0.14	0.18	7.13	6.69	0.14	0.18	0.11	0.14	4.39	6.24	0.22	0.20

Table 2. Growth and yield attributes of direct seeded rainfed upland rice as influenced by pre-conditioned urea and levels of N

Treatment	Grain yield (t/ha)			Straw yield (t/ha)			Biological yield (t/ha)			Harvest index		
	2003	2004	Pool	2003	2004	Pool	2003	2004	Pool	2003	2004	Pool
N (Kg/ha)												
30	3.36	3.59	3.47	3.56	3.68	3.62	6.92	7.27	7.09	48.55	49.38	48.96
60	3.81	4.02	3.91	4.12	4.29	4.20	7.93	8.31	8.12	48.04	48.57	48.20
90	4.12	4.29	4.20	4.43	4.59	4.51	8.55	8.88	8.71	48.18	48.31	48.24
CD (P=0.05)	2.12	3.06	4.12	3.39	5.04	4.81	8.89	9.01	7.62	Ns	Ns	Ns
Pre-conditioned urea	3.59	3.71	3.65	3.79	3.81	3.80	7.38	7.52	7.45	48.64	49.33	48.98
Prilled urea												
Urea + saw dust + soil (1:3:1)	3.92	3.88	3.80	3.90	3.98	3.94	7.82	7.86	7.84	50.12	49.36	49.74
Urea + rice husk + Soil (1 :3:1)	3.81	3.96	3.88	4.02	4.18	4.09	7.83	8.14	7.98	48.65	48.64	48.64
Urea + wheat husk+ soil (1:3:1)	3.89	4.04	3.96	4.19	4.36	4.27	8.08	8.40	8.24	48.14	48.09	48.11
Urea + FYM + soil (1 :3:1)	4.19	4.26	4.22	4.46	4.65	4.55	8.65	8.91	8.78	48.43	47.81	48.12
CD (p= 0.05)	5.24	3.86	2.89	4.03	6.26	3.85	6.36	7.08	4.89	Ns	Ns	Ns

Table 3. Growth and yield attributes of direct seeded rainfed upland rice as influenced by pre-conditioned urea and levels of N

Treatment	Weed population (No/ m^2)						Dry weight of weeds (g/m^2)					
	At 45 DAS			At harvest			At 45 DAS			At harvest		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pool
N (kg/ha)												
30	162.26	174.9	168	154.8	144.5	149.6	28.8	36.3	32.5	50.0	58.0	54.0
60	180.2	190.4	185	166.9	170.4	168.6	34.2	41.8	38.0	62.0	70.0	66.0
90	210.4	230.3	220	190.6	206.7	198.6	39.4	48.7	44.0	79.0	88.0	83.5
CD (P=0.05)	0.4	0.6	0.5	0.3	0.5	0.4	0.7	0.9	0.8	0.4	0.9	0.65
Pre-conditioned urea	184.3	191.2	187.5	171.3	180.3	175.5	40.6	45.1	42.8	64.1	72.9	68.5
Prilled urea												
Urea + saw dust + soil1 (1:3:1)	68.8	176.4	172.6	157.4	169.6	163.5	36.3	41.8	39.0	60.3	66.5	63.4
Urea + rice husk + soil (1 :3:1)	158.5	166.3	162.4	146.6	158.4	152.5	33.7	37.9	35.8	54.0	58.0	56.0
Urea + wheat husk+ soil (1:3:1)	146.4	151.4	148.5	137.8	145.2	141.5	28.6	35.2	31.9	42.1	46.8	44.45
Urea + FYM + soil (1 :3:1)	144.2	148.5	146	138.5	142.3	140.4	37.3	44.9	41.1	68.2	71.6	69.9
CD (p= 0.05)	0.8	0.6	0.7	0.3	0.5	0.4	0.7	0.3	0.5	0.4	0.6	0.5

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Table 4. Nitrogent content, accumulation and available soil N at harvest as influenced by pre-conditioned urea and N levels

Treatment	NContent (%)						N accumulation (qrain { straw) (kg/ha)		Available N at harvest (kg/ha)	
	30 Days		60 Days		harvest					
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
N (kg/ha)										
30	1.98	2.01	1.42	1.49	0.42	0.46	75.23	76.74	212	225
60	2.10	2.12	1.58	1.61	0.49	0.54	84.38	87.29	230	243
90	2.15	2.18	1.64	1.66	0.56	0.58	92.69	96.74	239	251
CD (P=0.05)	0.05	0.08	0.07	0.05	0.03	0.05	4.23	5.39	3.39	5.35
Pre-conditioned urea	2.06	2.09	1.54	1.56	0.45	0.46	84.26	87.38	221	235
Prilled urea										
Urea + saw dust + soil (1:3:1)	2.10	2.13	1.70	1.71	0.51	0.56	97.12	99.76	235.0	250.0
Urea + rice husk + soil (1 :3:1)	2.12	2.16	1.74	1.75	0.53	0.54	101.36	103.34	239.0	255.0
Urea + wheat husk+ soil (1:3:1)	2.13	1.18	1.80	1.81	0.56	0.59	104.55	105.94	242.0	260.0
Urea + FYM + soil (1 :3:1)	2.15	2.22	1.84	1.87	0.62	0.63	108.49	11.88	251.0	266.0
CD (p= 0.05)	NS	0.03	0.10	0.12	0.05	0.08	7.36	8.09	9.12	12.46

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GENETIC VARIABILITY STUDY FOR YIELD CONTRIBUTING TRAITS IN PUMPKIN (*CUCURBITA MOSCHATA*)

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ABSTRACT

Genetic variability, heritability and genetic advance for different yield contributing characters were studied in 24 genotypes of pumpkin. The study indicated existence of considerable amount of genetic variability for all the characters studied except flesh thickness. Days to anthesis of 151 male flower exhibited highest values of genotypic coefficient of variation and phenotypic coefficient of variation (GCY and PCV). High estimates of heritability (broad sense), genotypic coefficient of variation (GCY) and genetic advance were observed for days to anthesis of 151 male flower, fruit weight, fruit yield per plant and total fruit yield per hectare. These characters can be effectively improved through selection.

Key words : : Heritability, genetic advance, GCV and PCV.

Pumpkin is one of the important vegetable which has special place due to its high productivity, nutritive value, good storability, long period of availability and better transport potentialities. Matured fruits are also used as industrial raw material for carotene production (Vucetic *et al.*, 1989). Pumpkin has some medicinal properties. It helps to alleviate cardiovascular diseases and constipation of stomach or intestines and is a good diuretic food. Its combination with sugar and honey has soothing effect to ulcers and blisters and dried pulps are also used in cases of lungs bleeding and some other bleeding problems (Chaturvedi and Chatervedi, 2001). It is used in treatment of diabetes, rheumatism, eczema and burns, and against worms and other parasites (Vucetic *et al.*, 1989). The seeds with sugar and castor oil are given to the patients suffering from tapeworm (Chaturvedi and Chatervedi, 2001).

The exploration of genetic variability in the available germplasm is a pre-requisite in a breeding programme for effective selection of superior genotype. The partitioning of total variability into heritable and non heritable components by using suitable design will enable the breeder to know whether the superiority of selection is inherited by the progenies. Since natural genetic variation for most of the yield attributes is considerably high in pumpkin, there is an urgent need of information on the nature and magnitude of variation available in the material and part played by environment in expression of different characters. Keeping in view the above facts, the present investigation was undertaken to estimate the magnitude of heritable and non-heritable component of variation and genetic parameters such as genotypic coefficient of variation, heritability, and genetic advance in twenty four diverse germplasm of pumpkin.

MATERIALS AND METHODS

The present investigation was carried out at the Vegetable Research Centre, G.B.P.U.A & T., Pantnagar during summer 2006 and summer 2007. Twenty four germplasm collected from different parts of India were taken for the study. The experiment was laid out in a randomized block design with three replications. Sowing was done in mid February. The plot size was 7 x 3 m and each genotype consisted of a single row having 7 plants at a spacing of 3 x I m and all the recommended agronomic package of practices were followed. The observations were recorded on five randomly selected plants per replication for each germplasm on eighteen important characters including total fruit yield per hectare during summer 2006 and summer 2007 respectively. The pooled data of two years (2006 and 2007) was used for statistical analysis. The analysis of variance was carried out as suggested by Panse and Sukhatme (1967) and was used for calculating other genetic parameters. Genotypic and phenotypic coefficient of variation were calculated as per formula suggested by Comstock and Robinson (1952). Heritability in broad sense and expected genetic advance were calculated as per Allard (1960) and Johnson *et al.* (1955) respectively.

RESULTS AND DISCUSSION

Analysis of variance was highly significant for all the characters. High level of variability was recorded for all the 18 characters studied among twenty four genotypes of pumpkin. The pooled mean value of two years (2006 and 2007) for 18 traits is presented in Table-1. Vine length varied from 3.93m (PPU-56) to 7.83m (CM-71), no. of primary branches per vine from 8.20 (PPU-149) to 15.86 (PPU-46), node of 1 st male flower appear from 1.56 (PPU-140) to 6.05 (CM-83), node of 1 st female flower appear from 11.08 (PPU-140) to 15.56 (PPU-175), days to anthesis of 1st male flower from 57.65 days (PPU-197) to 74.48 (CM-83), days to anthesis of 1 st female flower from 60.23 days (PPU-140) to 71.85 days (PPU-175), sex ratio from 6.29 (CM-83) to 17.71 (PPU-39), polar diameter of fruit from 20.96cm (PP-I13) to 45.95cm (PPU-39), equatorial diameter of fruit from 14.35cm (PP-I13) to 27.55cm (PPU-260), polar diameter of seed cavity from 15.13cm (PP-113) to 36.51cm (PPU-39), equatorial diameter of seed cavity from 8.35cm (PPU-143) to 18.01cm (PPU-197), flesh thickness from 2.73cm (PPU-175) to 5.08cm (PPU-260), fruit weight from 2.45kg (PP-113) to 11.28kg (PPU260), fruits per plant from 0.93 (PPU-260) to 1.90 (CM-71), fruit yield per plant from 3.38kg (PP-113) to 12.58kg (PPU-146), 100 seed weight from 6.51g (PPU-185) to 20.43g (CM-83), seeds per fruit from 211.83 (PPU-276) to 518.16 (CM-83) and total fruit yield from 112.76q/ha (PP-I13) to 416.40q/ha (PPU-146) as per pooled analysis over both the years. Kumar (2004) and Mandal (2005) also reported wide range of variation for most of the characters studied in this crop. The extent of variability present in twenty four germplasm of pumpkin was measured in terms of phenotypic variance (σ^2_p), phenotypic coefficient of variation (PCY), genotypic variance (σ^2_g), genotypic coefficient of variation (GCY), heritability (broad sense) and genetic advance (GA) (Table-2). The GCY which gives a picture of extent of genetic variability in the population ranged from 15.32 per cent (flesh thickness) to 50.96 per cent (days to synthesis of 1st male flower). The GCY values were considerably high for characters such as fruit weight, days to synthesis of 1 st female flower, fruit yield per plant, total fruit yield per plant and node of 1 st male flower appear. These characters having higher range of variation have a better scope of improvement through selection. This finding is in agreement with those reported by Kumar (2004). A perusal of data in Table 2 shows that there was close relationship between PCV and GCV was low for all the characters which indicated less influence of environment for most of the characters.

With the help of GCV alone, it is not possible to determine the amount of variation that is heritable. Heritable variation can be found out with greater degree of accuracy when heritability is studied in conjunction with genetic advance.

Heritability estimates in pooled analysis revealed that high estimates (more than 80%) were observed for seeds per fruit (97.36), total fruit yield per hectare (97.27), fruit yield per plat (96.99), 100 seed weight (96.34), fruit weight (95.58), vine length (95.27), equatorial diameter of seed cavity (95.00), polar diameter of fruit (94.54), polar diameter of seed cavity (93.48), no. of primary branches per vine (92.53), equatorial diameter of fruit (92.35), node of I st female flower appear (91.44), sex ratio (91.08), fruits per plant (90.47) and node of 1 st male flower appear (90.29). Moderate estimates of heritability (50-80%) were observed for flesh thickness (79.13) and days to anthesis of 1st male flower (77.24) and low heritability (less than 50%) was observed for days to anthesis of 1st female flower (47.99).

The heritability estimates of flesh thickness

Table 1. Mean value for 18 quantitative characters pooled over two years (Summer 2006 and Summer 2007)

S. N.	Genotypes	Vine length (m)	No.of primary branches Vine	Node of I make flower open	Node of 1 female flower open	Days of 1 female flower open	Days of 1 female flower open	Sex ratio	Polar diameter of fruit (cm)	Equatorial diameter of fruit (cm)	polar diameter of seed cavity (cm)	Euqatorial diameter of seed cavity (cm)	Flesh thickness (cm)	Fruit weight (kg)	Fruits plant	Fruit yield plant (kg)	100 seed weight (g)	Seeds/ fruit	Total Fruit yield (q/ha)
1	PPU -175	6.87	12.62	2.81	15.56	67.26	71.85	10.23	22.85	17.78	17.38	12.31	2.73	4.20	1.29	5.45	17.75	442.16	181.64
2	PPU -46	4.21	15.86	2.66	13.21	62.67	68.40	15.95	27.96	17.20	20.03	9.26	3.96	5.76	1.88	10.85	19.96	421.50	361.85
3	PPU -174	7.12	14.35	2.70	12.78	64.61	64.64	10.21	26.95	18.48	19.38	10.91	3.78	4.42	1.49	6.59	19.13	363.66	219.64
4	PPU -146	4.08	9.38	1.90	13.50	64.71	62.96	11.02	28.75	25.86	20.80	17.96	3.95	8.05	1.54	12.58	18.53	464.50	416.40
5	PPU -150	5.13	11.28	2.20	13.91	65.63	66.65	11.83	26.70	20.31	18.70	12.31	4.00	4.91	1.41	6.83	14.16	419.50	227.92
6	CM-83	7.11	15.53	6.05	11.90	74.48	64.25	6.29	29.83	21.45	22.96	14.58	3.43	4.33	1.58	6.88	20.43	518.16	229.42
7	PPU -197	7.54	10.95	2.91	13.72	57.65	62.53	9.28	32.26	26.75	23.53	18.01	4.36	8.30	1.27	10.55	15.70	438.00	351.63
8	PPU -149	3.95	8.20	2.61	11.21	62.92	62.05	10.44	22.55	17.10	16.55	11.10	3.00	2.95	1.87	5.51	17.16	315.66	183.86
9	PPU -199	4.92	8.86	2.08	12.91	64.68	63.20	12.22	33.51	23.66	23.71	13.86	4.90	9.54	1.26	12.03	19.05	352.83	401.18
10	CM-71	7.83	13.19	5.40	14.63	74.20	66.16	10.94	27.46	17.98	19.50	10.01	3.98	4.38	1.90	8.37	14.45	412.83	279.02
11	PPU -138	4.75	8.63	2.93	13.69	64.37	64.20	10.58	25.68	18.01	17.68	10.01	4.00	5.86	1.36	8.00	17.51	353.00	266.85
12	PP- 113	4.24	14.81	2.95	11.41	66.40	67.06	10.87	20.96	14.35	15.13	8.51	2.9i	2.45	1.38	3.38	17.58	248.33	112.76
13	PPU -189	4.19	9.51	2.51	11.33	62.78	60.66	8.13	24.81	15.45	18.28	8.91	3.26	4.45	1.81	8.08	16.41	316.83	269.41
14	PPU -195	5.20	15.56	2.53	12.90	63.60	64.86	10.81	24.95	25.28	16.48	16.81	4.23	6.03	1.76	10.62	9.90	330.16	353.96
15	PPU -39	7.09	10.90	2.70	14.96	63.15	65.46	17.71	45.95	24.61	36.51	15.18	4.71	6.71	0.98	6.63	7.31	366.50	220.59
16	PPU -276	4.12	8.49	2.85	12.00	67.46	67.05	14.86	22.18	18.80	15.75	12.20	3.30	3.65	1.09	4.16	13.26	211.83	138.65
17	PPU -140	4.05	8.68	1.56	11.08	61.95	60.23	7.33	29.06	25.81	19.53	16.11	4.76	6.20	1.25	7.75	14.93	259.00	258.30
18	PPU -144	5.21	9.73	2.85	11.73	64.06	64.71	11.99	28.05	24.58	19.60	16.46	4.05	8.14	1.14	9.30	12.73	283.00	309.97
19	PPU -60	4.29	12.41	2.63	12.28	64.07	66.16	12.64	23.45	21.86	15.56	13.98	3.94	6.54	1.14	7.44	12.56	318.50	248.31
20	PPU -185	4.46	10.71	3.01	11.81	65.45	65.55	8.12	25.20	16.43	17.40	8.63	3.90	4.45	1.55	6.68	6.51	368.66	222.75
21	PPU -182	4.53	12.81	2.50	12.71	64.09	64.11	9.92	26.23	20.40	17.93	12.10	4.15	5.98	1.04	6.26	15.10	469.00	208.86
22	PPU -56	3.93	13.38	2.66	11.50	63.63	65.48	11.26	26.00	18.81	19.33	12.15	3.33	4.45	0.99	4.43	14.56	356.66	147.76
23	PPU -260	4.14	11.70	2.70	15.35	65.52	70.98	7.97	36.55	27.55	26.13	17.38	5.08	11.28	0.93	10.56	10.03	486.50	352.18
24	PPU -143	4.93	12.62	2.97	13.53	65.78	67.00	11.90	24.10	15.35	17.10	8.35	3.50	4.40	1.11	4.89	11.38	505.66	163.20
Range		3.93-7.83	8.20-15.86	1.56-6.05	11.08-15.56	57.65-74.48	60.23-71.85	6.29-17.71	20.96-45.95	14.35-27.55	15.13-36.51	8.35-18.01	2.73-5.08	2.45-11.28	0.93-1.90	3.38-12.58	6.51-20.43	211.83-518.16	112.76-416.40
Grand Mean		5.16	11.67	2.86	12.90	65.05	65.26	10.94	27.58	20.58	19.79	12.80	3.88	5.72	1.38	7.66	14.84	375.93	255.25
SEm±		0.16	0.39	0.17	0.38	1.03	1.43	0.46	0.73	0.66	0.68	0.41	0.17	0.25	0.56	0.25	0.42	7.85	8.08
CV		5.57	5.87	10.72	5.16	2.76	3.79	7.37	4.63	5.55	5.95	5.65	7.86	7.62	7.08	5.78	4.99	3.62	5.48
CD(0.05)		0.47	1.12	0.50	1.09	2.95	4.07	1.32	2.10	1.88	1.93	1.19	0.50	0.71	0.16	0.72	1.21	22.37	23.01
CD 0.01)		0.63	1.50	0.67	1.46	3.94	5.43	1.77	2.80	2.50	2.58	1.58	0.67	0.95	0.21	0.97	1.62	29.86	30.72

Table 2. Variability parameters for different characters in pumpkin pooled over two years (Summer 2006 and Summer 2007)

S. N.	Characters	Genotypic coefficient of variation (GCV)%	Phenotypic coefficient of variation (PCV)%	Heritability (%)	Genetic advance (G.A.)	Genetic advance (G.A.) as % of mean
1	Vine length (m)	25.04	25.65	95.27	2.60	50.38
2	No. of primary branches per vine	20.67	21.49	92.53	4.78	40.95
3	Node of 1 st male flower appear	32.72	34.43	90.29	1.83	63.98
4	Node of 1 st female flower appear	24.20	25.91	91.40	8.50	65.89
5	Days to anthesis of 1 st male flower	50.96	57.98	77.24	60.02	92.26
6	Days to anthesis of 1st female flower	36.45	52.62	47.99	33.95	52.04
7	Sex ratio	23.58	24.71	91.08	5.07	46.34
8	Polar diameter of fruit (em)	19.28	19.82	94.54	10.65	38.61
9	Equatorial diameter of fruit (em)	19.31	20.10	92.35	7.87	38.24
10	Polar diameter of seed cavity (em)	22.54	23.31	93.48	8.88	44.87
11	Equatorial diameter of seed cavity (em)	24.68	25.32	95.00	6.34	49.53
12	Flesh thickness (em)	15.32	17.22	79.13	1.09	28.09
13	Fruit weight (kg)	36.71	37.49	95.58	4.24	74.12
14	Fruits/plant	21.84	22.96	90.47	0.59	42.75
15	Fruit yield/plant (kg)	32.84	33.34	96.99	5.10	66.57
16	100 seed weight (g)	25.64	26.12	96.34	7.69	51.81
17	Seeds/fruit	22.02	22.32	97.36	168.32	44.76
18	Total fruit yield (q/ha)	32.78	33.23	97.27	170.00	66.60

and days to anthesis of 1 st male flower were moderate where as days to anthesis of 1 st female flower was of low level suggesting that the environmental effects constitute a major portion of total phenotypic variation and hence direct selection for this character will be less effective.

Expected genetic advance and its estimates as percentage of mean for various characters revealed that high genetic advance (more than 50%) was obtained for days to anthesis of 1 Sl male flower (92.26) followed by fruit weight (74.12), total fruit yield per hectare (66.57), node of 1 sl female flower appear (65.89), node of 1 sl male flower appear (63.98), days to anthesis of 1 Sl female flower (52.04), 100 seed weight (51.81) and vine length (50.38).

Moderate genetic advance as percent of mean (25-50%) was obtained for equatorial diameter of seed cavity (49.53), sex ratio (46.34), polar diameter of seed cavity (44.87), seeds per fruit (44.76), fruits per plant (42.75), no. of primary branches per vine (40.95), polar diameter of fruit (38.61), equatorial diameter of fruit (38.24) and flesh thickness (28.09).

Though characters such as equatorial diameter of seed cavity, sex ratio, polar diameter of seed cavity, seeds per fruit, fruits per plant, no. of primary branches per vine, polar diameter of fruit, equatorial diameter of fruit and flesh thickness had moderate to high heritability values but their GCV was comparatively less resulting in less genetic advance. This confirms the findings of Dahiya *et al.* (1990) that GCV together with heritability estimates would give a better picture of genetic advance to be expected from selection. Swarup and Changale (1962) also pointed out that high heritability was not always accompanied with high genetic advance. If heritability was mainly owing to non-additive gene action, lower genetic advance could be expected. The characters like node of 1 sl male flower appear, fruit weight, fruit yield per plant and total fruit yield per hectare possessing high GCV, heritability and genetic advance could be effectively used for selection in pumpkin as it had been suggested by several other authors also viz. Dahiya *et al.* (1990), Kumaran *et al.* (1997), Mohanty and Mishra (1999), Bindu *et al.* (2000), Pandey *et al.* (2002), Lakshmi *et al.* (2002), Kumar (2004) and Mandal (2005). Characters with high heritability coupled with high genetic advance would response to selection better than those with high heritability and low genetic advance. The moderate to high heritability and low genetic advance values observed in other characters namely flesh thickness, days to anthesis of 1 sl male flower, days to anthesis of 1 sl female flower, equatorial diameter of seed cavity, sex ratio, polar diameter of seed cavity, seeds per fruit, fruits per plant, no. of primary branches per vine, polar diameter of fruit and equatorial diameter of fruit that the expression of these characters was governed by non-additive gene action.

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HETEROSIS AND INBREEDING DEPRESSION IN INDIAN MUSTARD [*BRASSICA JUNCEA* (L.) CZERN & COSS]

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ABSTRACT

The average heterobeltiosis for seed yield and oil content per plant pooled over two rabi seasons of 2003-04 and 2004-05 was 39.51 and 5.38% respectively. Based on per se performance and heterotic response for seed yield and oil content, the selected best crosses of thirty six were viz., T-59 x RH-30, T-59 x RL-1359, RH-30 x Pusa Bold, RH-30 x RL-159, RH-30 x RW-351 and RL-1359 x Pant Rai-16. Response of inbreeding depression for many yield promoting traits was significant in positive direction and ranged from 14.61% to 40.42% for seed field and 0.51% to 8.03% for oil content.

Key words : Indian mustard, diallel, heterosis, inbreeding depression.

Indian mustard or rai [*Brassica juncea* (L.) Czern & Coss] has been a vital source of edible oil to millions of people living in rural and semi urban areas of the country. In India, it is an important rabi crop that yields cooking oil whi8ch is highly palatable and digestible as for as the nutritional quality is concerned. The desirable characters in mustard variety are number of primary and secondary branches, main raceme length siliqua number, siliqua length and test weight besides high seed and oil yielding potentiality. The major goal of any crop improvement programme is to upgrade these traits through heterosis breeding. The comparative information on the extent of inbreeding depression in this crop is very useful. It usually provides the valuable indication about how much the grower will lose in terms of seed yield or oil content, if he prefers to grow the F_2 seeds of their home grown commercial from F_1 hybrid. The magnitude of inbreeding depression from F_1 to F_2 also genetically indicates that those crosses, which show high degree of inbreeding depression for seed yield contain a higher component of non-additive gene action and those showing lower values of inbreeding depression, could have predominantly higher amount of additive genetic component. Though some work has already been done to improve mustard yield in our country, yet the potential is yet to be realized. The present investigation has been undertaken to study the heterosis in F lover better parent (BP), mid parent (MP) and standard check (SD) and inbreeding depression over F_2 segregating generations for seed yield, its related characters and oil content in some intervarietal crosses of Indian mustard.

MATERIALS AND METHODS

The present study was pursued at the Agricultural Research form of Narain College, Shikohabad affiliated to Dr. B.R.A. University, Agra during *rabi* seasons in the years 2003-04 and 2004-2005. The experimental material consisted of thirty six crosses (F_1s and F_2s) developed through diallel mating design excluding reciprocals involving nine diverse strains of Indian mustard collected from National Research Centre on Rapeseed-Mustard, Sewar, Bharatpur (Raj.) in October, 2000. The F_1s and F_2s of thirty six crosses with nine parents and one standard check variety (Kranti) were planted in complete randomized block design with three replications on November 5, 2003. The plot size of each cross combination consisted of parents and check. (one row), F_1 hybrids (one row) and F_2 segregating populations (three rows). The row length was kept at 4 meters and were maintained at 45 x 15 cm as inter and intra row spacing, respectively. A basal dose of fertilizers @ 40 : 20 : 20 NPK kg/ ha was applied just before seed sowing.

Recommended agronomic practices and plant protection measures were followed to rai.se a good and healthy crop under irrigated condition.

Ten competitive plants were randomly selected from parents, check variety and F_1 and 20 plants from F_2 population in each plot and also in each replication. Observations were recorded for days to first flower (mean in days on row basis), plant height (cm), main raceme length (cm), number of primary branches/plant, number of secondary branches/plant, number of siliquae on main raceme, siliqua length (cm), 1000-seed weight (g), seed yield / plant (g) and oil content per plant (%). The oil content/plant in per cent was measured by using official methods of analysis of the Association of Official Analytical Chemists (AOAC, 1985). The mean of different characters for the purpose of statistical analysis have been calculated on the basis of the individual data recorded for each character in each replication separately for each cross. The heterosis over better parent, mid parent and standard variety were estimated as deviation of F1 value from the better parent, mid-parent and standard variety for all characters.

$$[\{\overline{F_1}-\overline{BP}\}/\overline{BP}x100],\ [\{\overline{F_1}-\overline{MP}\}/\overline{MP}x100]$$
$$\text{and } [\{\overline{F_1}-\overline{SV}\}/\overline{SV}x100$$

Heterosis significance was tested by 't' test.

RESULTS AND DISCUSSION

Variable magnitude of three types of heterosis *viz.*, relative heterosis, heterobeltiosis and standard heterosis as exhibited by different cross combinations for all the characters indicated sufficient variability in parental material for these traits (Table 1). For commercial exploitation of heterosis for seed yield and oil content, ten crosses *viz.*, T-59 x RH-30, T-59 x RL-1359, RH-30 x Pusa Bold, RH-30 x RL-I359, RH-30 x RW-351, RH-30 x JGM-01-15, Pusa Bold x JGM-01-15, Pusa Bold CS-52, RL-I359 x RW-351 and RL-1359 x Pant Rai-16 were indentified as the best hybrid combinations as they showed significant heterosis in desirable direction over the standard check, the commercially released hybrid 'Kranti'. The magnitudes of standard

Table 1. Summary of heterotic effects for ten characters in Indian mustard pooled over two crop seasons

Characters		Days to flower			Plant height			Main raceme length			Primary branches			Secondary branches			Siliquae on main raceme			Siliqua length			Test weight			Seed yield! plant			Oil content		
Type of Heterosis		MP	BP	SD	MP	BP	SD	MP	BP	SD	MP	BP	SD	MP	BP	SD	MP	BP	SD	MP	BP	SD	MP	BP	SD	MP	BP	SD	MP	BP	SD
Sig. + ve		6	16	10	24	10	08	36	30	11	34	24	16	36	25	19	31	26	12	29	24	08	36	25	10	35	28	19	28	20	14
Sig. - ve		13	3	6	0	2	0	0	0	0	1	4	1	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0
Total sig.		19	19	16	24	12	08	36	30	11	35	28	17	36	25	19	31	26	12	29	25	08	36	27	10	35	28	19	28	20	14
Range	L	-3.05			-5.67			5.78			-3.85			10.76			6.95			3.19			4.50			8.75			1.35		
MP%	H	18.16			16.10			55.05			121.80			134.15			55.06			21.65			43.68			131.22			12.18		
BP%	L	-10.55			-12.25			0.78			-6.11			-10.08			6.44			-4.11			-6.33			-2.42			-0.85		
	H	34.12			14.75			51.75			105.55			120.65			52.26			12.95			34.25			105.75			6.59		
SD%	L	-15.07			-5.95			2.89			-5.09			9.18			5.54			2.62			-5.20			-3.21			-0.52		
	H	12.65			16.56			32.05			48.75			55.30			13.15			9.35			15.35			46.48			4.55		

+ ve and - significant at 5 % level. MP= Mid parent, BP= Better parent, SD= Standard check.
L and H denotes lower and upper range of estimates, respectively.

heterosis (SD) for seed yield/plant and oil content ranged from -3.21% to 46.48% and -0.52% to 4.55%, respectively. Among the ten characters study, extent of heterobeltiosis for seed yield per plant was observed significant in 28 crosses out of 36 and ranged from -2.42% to 105.75% while over mid-parent it ranged from 8.75% to 131.22% being significant in 35 crosses. Better parent and mid-parent heterosis for oil content was observed positively significant in 20 and 28 crosses and the estimates ranged from -0.85% to 6.59% and 1.35% to 12.18%, respectively. There is consistency in the results obtained and those reported by Brandle and Mc Vetty (1989) and Tyagi *et al.* (2001).

Incidently the indentified set of above ten crosses also showed significant heterosis over better parent as well as mid-parental values for seed yield and oil content indicating the presence of non-additive gene action (dominance and epistasis) (Table 2). For seed yield per plant maximum positively significant heterobeltiosis was observed in the cross RH-30 x RW-351 (105.75%) followed by T-59 x RL-1359 (80.55%) and RH-30 x RL-I 359. (74.75%). For oil content percent plant maximum better parent heterosis was recordedin the cross T-59 x hybrids were also superior in per se perfomance and it was observed that for almost all the important yield contributing traits, there was a good correspondance between high heterotic values and the per se performance of the crosses.

Heterosis for sink potential and seed yield is being manifested as the cumulative effect of heterosis for component traits. In the present investigation, the elaborative study of ten best crosses revealed this fact as most of the crosses that showed positive and significant heterosis for seed yield and oil content, also showed for secondary branches, primary branches, Siliquae on main raceme, main raceme length, 1000-seed weight and siliqua length, the major yield contributing components (Table 3). The results of the present study also revealed that the magnitudes of heterosis computed over mid-parent and over better parent for two successive years brought about only quantitative differences and, by an large, there was no significant deviation in the direction of heterotic expression. The findings of the present investigation on the magnitude and direction of heterosis for seed yield and oil content are in agreement with the earlier reports. Majority of the crosses exhibited moderate to high positive heterosis over better parent for various yield components except days to flower (where negative direction of heterosis

Table 2. Best crosses on the basis of per se performance and beterosis (%) for seed yield and oil content in *B. Juncea*

Crosses	Per se performance		Heterosis (%)					
			Seed yield/ plant (g)			Oil content/ plant (%)		
	SY	OC	MP	BP	SD	MP	BP	SD
T-59 x RH-30	16.35	42.7	88.44**	65.75**	36.25**	10.55**	6.59**	4.50**
T-59 x RL-1359	17.54	41.6	131.22**	80.55**	46.48**	12.18**	6.25**	4.05**
RH-30 x Pusa Bold	14.65	41.2	59.88**	50.27**	32.55**	9.26**	5.12**	4.15**
RH-30 x RL-1359	15.58	42.5	102.87**	74.75**	43.75**	10.12**	6.28**	4.35*
RH-30 x RW-35 1	15.92	40.2	124.72**	105.75**	25.28**	9.56**	6.00**	4.55**
RH-30 x JGM-Ol-15	13.75	40.5	73.15**	71.51**	40.37**	8.29**	5.68**	3.85**
Pusa Bold x JGM-Ol-15	13.36	40.6	70.13**	58.49**	30.05**	6.78**	3.75**	3.45**
Pusa Bold xeS-52	13.63	41.2	80.65**	61.66**	21.55**	7.35**	4.70**	2.25*
RL-1359 x RW-351	12.36	41.8	65.08**	57.62**	24.15**	8.55**	5.75**	3.75**
RL-1359 x Pant Rai-16	12.72	40.6	68.06**	56.77**	37.15**	8.06**	4.18**	3.55**

*, ** significant at 5% and 1% level, respectively.

Table 3. **Summary of desirable pooled heterotic effect and estimates of inbreeding depression of crosses for yield and component characters in *B. juncea*.**

Crosses		Days to flower	Plant height (cm)	Main raceme length	Primary branches	Secondary branches	Siliquae on main	Siliqua length raceme	Test weight (g)	Seed yield	Oil content plant
		DF	PH	MRL	PB	SB	Sq/MR	SqlL	TW	SY	OC
T-59 x RH-30	H	*	**	**	**	**	**	**	**	**	**
	ID	3.27	11.19**	12.06**	15.66**	21:26**	21.48**	11.99**	3.89*	22.71**	3.22**
T-59 x RL-1359	H	**	--	**	**	**	**	**	**	**	**
	ID	8.57**	4.37	5.36**	47.80**	65.20**	1.30**	15.89**	7.64**	40.42**	8.03**
RH-30 x Pusa Bold	H	--	NS	**	**	**	**	**	*	**	**
	ID	-0.83	7.96**	2.66	28.17**	36.25**	17.71**	14.65**	3.02*	23.96**	2.51*
RH-30 x RL-1359	H	NS	NS	**	**	**	**	--	**	**	**
	ID	8.27**	15.86**	4.98**	36.91 **	49.87**	13.23**	9.30**	16.55**	32.26**	6.75**
RH-30 x RW-351	H	**	--	**	**	**	**	--	**	**	**
	ID	-7.01*	4.13	7.15**	43.70**	39.01 **	17.71**	18.40**	7.59**	36.08**	3.90**
RH-30 x JGM-OI-15	H	**	*	**	**	**	NS	**	**	**	**
	ID	-7.82*	10.29**	14.51**	25.96**	44.76**	25.37**	17.03**	-2.20	24.30**	6.27**
Pusa Bold x JGM-OI-15	H	*	**	**	**	**	**	**	**	**	**
	ID	-3.78	5.33	27.96**	35.41 **	41.39**	24.65**	9.66**	9.50**	15.76**	3.12**
Pusa Bold xeS-52	H	NS	NS	**	**	**	**	**	**	**	**
	ID	11.71**	3.46	30.03**	40.00**	16.75**	27.81 **	7.32**	6.52**	37.82**	5.05**
RL-1359 x RW-351	H	**	-**	**	-**	NS	**	**	**	**	**
	ID	-7.93**	4.39	13.83**	13.92**	37.50**	16.18**	16.85**	10.68**	6.62	1.75
RL-"1359 x Pant Rai-16	H	NS	NS	**	-**	--	**	**	-**	**	**
	ID	-4.31	8.12**	6.16**	-35.09**	34.74**	10.75**	12.25**	4.92**	15.74*	2.46*

* ** significant at 5% and 1% level, respectively.
H : Heterotic effect, ID : inbreeding depression.

was desirable) and plant height where very few cross combinations recorded significant heterosis which could be desirable. The highest desirable heterosis observed over better parent for various component characters were -10.95% for days to first flower, 14.75% for plant height, 51. 75% for main raceme length, 104.83% for primary branches, 120.65% for secondary branches, 55.06% for siliquae on main raceme, 12.95% for siliqua length and 34.25% for 1000-seed weight. Presumably the higher degree of dominance coupled with epistatic interactions might have been responsible for higher magnitude of heterosis exhibited by the component traits of seed yield. Similar findings are also reported by Pradhan *et al.* (1993), Katiyar *et al.* (2000) and Swamkar *et al.* (2001).

One of the characteristics of heterosis is that the increase in vigour is confirmed to F_1 generation. There is considerable depression from F_1 to F_2 and later generations. The pooled results obtained in this study about inbreeding depression have been briefly presented in Table 3, which indicated that higher estimates of heterosis were positively associated with substantial inbreeding depression for most of the major yield components in *Brassica juncea*. In present study, 71.66% of the total better parent heterotic hybrids for seed yield/plant and 79.42% for oil content/plant exhibited significant inbreeding depression in F_2 generation. The magnitude of inbreeding depression varied for seed and oil yield from -3.21 % to 40.42% and -0.52% to 4.15% with an average of 18.07% and 12.16%, respectively. Similar findings were also reported by Singh and Rai (1995).

For the characters number of primary and secondary branches, number of siliquae on main raceme, seed yield and oil content per plant, there was a marked inbreeding depression but for 1000-seed weight, siliqua length, main raceme length, plant height and days to flower the value of inbreeding depression obtained was lower in magnitude. In many investigations, expression of seed yield in *Brassica juncea* has been reported that it is predominantly governed by non-additive gene action while 1000-seed weight is pre-dominantly controlled by addititive gene action. Therefore, the above reported behaviour of inbreeding depression is expected. (Kumar *et al.*, 1990, Pradhan, 1999; Katiyar *et al.* 2000 and Ghosh *et al.*, 2000).The crosses showing low inbreeding depression and high per se values in F_2 than that of used check can be utilized for the development of commerical hybrids in Indian mustard. The crosses *viz.*, RL-1359 x RW-351 and RL-1359 x Pant Rai-16, have high F_2 per se performance and comparatively low inbreeding depression for seed yield and oil content. These crosses can be utilized successfully in breeding programme for the above purpose in this crop.

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GENETIC DIVERGENCE IN POTATO (*SOLANUM TUBEROSUM* L.)

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ABSTRACT

A set of 44 potato genotypes were studied for genetic divergence based on fifteen yield attributing characters. Results revealed that all the genotypes were grouped into five different clusters. The highest inter-cluster distance was exhibited between the cluster-II and V followed by cluster-IV & V and cluster-II & III. Genotypes in clusters- V had the highest mean tuber yields and the attributing traits viz. number of leaves, number of compound leaves, fresh weight of tubers, harvest index, number of tubers, per cent emergence, marketable yields and total tuber yields. All the genotypes included in present investigation, were indigenous, but their grouping in different clusters, suggested that genotypes did not follow the geographic distribution. Selection of parents based on genetic divergence thus may be effective while planning future breeding programme for improving tuber yield in potato.

Key words : Potato, genetic divergence, tuber yield.

Potato (*Solanum tuberosum* L.) is among the most important food crop among the vegetables. The history of potato is the testimony of the fact that whenever, there has been scarcity of food grains, potato has become the food security of people. Potato, because of its great utility, occupies a pre-eminent place amongst the crops and acknowledges as the "king of vegetables". The success of potato breeding programme depends on the identification of promising parental lines for making desired crosses and selection of superior genotypes from the progenies Luthra *et al.* (2005). Distantly related lines are assumed to be more complementary and produce more superior heterotic progenies. In the present investigation, genetic divergence among 44 genotypes of potato was evaluated under similar conditions to identify diverse parent and verify relationship between genetic divergence and performance of genotypes for tuber yield as per Luthra *et al.* (2005).

MATERIALS AND METHODS

A field experiment was conducted at the expForty four genotypes of potato obtained from CPRI and AICRP, Shimla maintained at Indira Gandhi Krishi Vishwa Vidyalaya, Raipur were evaluated in randomized complete block design (RCBD) with three replication in plots of 3.0mx 1.2m and 60x20cm spacing during *rabi* 2006-07. All The recommended package of practices was adopted to raise a good crop. The crop was harvested at 75 days after planting and observations were recorded on five plants in each genotypes and each replication and there means were calculated. The genetic divergence was estimated by Mahalanobis' D^2 statistics as described by Rao (1952). Based on D^2 values, the constellation of genotypes into clusters was done following Tocher's method. In potato, due to stagnate and pre-petuating nature of heterosis, parental selection is a crucial step in any breeding programme. Using statistics as proposed by Mahalonobis (1936) D^2 value were calculated among forty four potato genotypes in all possible combinations.

RESULTS AND DISCUSSION

On the basis of D^2 analysis, all the forty four genotypes were grouped into five different clusters. The maximum numbers of sixteen genotypes were included in cluster-III followed by twelve genotypes in cluster-I, ten genotypes in cluster-IV, four genotypes in cluster-II and the lowest two genotypes were included in cluster-V (Table 1).

The intra and inter-cluster divergence of all clusters has been presented in Table 2. Intra cluster D^2 values ranged from 1.676 (Cluster -V) to 3.043 (cluster-IV). The intra cluster distance was observed highest in cluster-IV (3.043), followed by cluster-II (2.936), cluster- III (2.864), cluster-I (2.588) and was recorded the lowest in cluster -V (1.676). However, the inter-cluster D^2 values varied from 2.503 (cluster-I and III) to 7.850 (Cluster-II and V). The highest inter-cluster distance was exhibited between the cluster-II and V (7.850) followed by cluster-IV & V (6.495), cluster-II and III (6.302), cluster-III and V (5.855), cluster-I and II (5.331), cluster-I and V (4.260), cluster-II and IV (4.252), cluster-III and IV (3.475) and the minimum intercluster distance was observed in between cluster-I and III (2.503). Above findings indicated that high inter-cluster distances were the main cause of diversity In composition of cluster and hence, can be exploited in hybridization programme.

Divergence reflecting in the material was also evidenced by an appreciable amount of desirable variation among clusters mean for

Table 1. Clustering pattern of different genotypes of potato

Cluster number	Number of genotypes included	Genotypes
I	12	Kufri Anand, Kufri Badshah, Kufri Sutlej, J/93 - 77, J/94 - 90, JX - 90, JX - 374, J/92 -159, J/95 - 227, MS/92 - 132, MS/92-209, MS/92 - 3146
II	4	MP/90 -83, MP/97 - 625, MP/97 - 637, J/93 - 139
III	16	Atlantic, Kufri Ashoka, Kufri Chandramukhi, Kufri Jawahar, Kufri Pukhraj, J/92 -148, J/93 -4, J/92 - 164, J/93 - 81, J/95-71, J/95 - 221, J/95 - 229, J/95 - 242, J/98 - 159, MS/92 - 3128, 92 - PT - 27
IV	10	Kufri Chipsona - I, Kufri Chipsona-III, MP/97 - 644, MP/97-921, MP/97 - 699, J/93- 58, MS/91 - 1326, KMS/95 - 117, DTP -1, B - 420 (2)
V	2	J/93 - 86, MS/95 - 1309

Table 2. Average inter and intra- cluster D2 values

Cluster number	I	II	III	IV	V
I	**2.588** (1.609)				
II	5.331 (2.309)	**2.936** (1.713)			
III	2.503 (1.582)	6.302 (2.510)	**2.864** (1.692)		
IV	3.235 (1.799)	4.252 (2.062)	3.475 (1.864)	**3.043** (1. 744)	
V	4.260 (2.063)	7.850 (2.802)	5.855 (2.42)	6.495 (2.548)	**1.676** (1.245)

* Figure given in diagonal bold is intra-cluster D^2 values and Figure in parenthesis in D2 Values.

different characters as shown in Table 3. Genotypes in clusters- V had the highest tuber yields (11.82) and the other characters like plant height (42.98), number of leaves (84.2), number of compound leaves (33.34), fresh weight of tubers (0.54), harvest index (409.48), number of tubers (11.56), per cent emergence (95.39), marketable yields (9.52). Hence these genotypes may be utilized in future breeding programme. The similar trend in diversity among potato genotypes has also been suggested by Mittal and Dixit (1992), Pandey and Gupta (1997), Desai and Jaimini (1995), Joseph *et al.* (1999), Sandhu and Kang (1998), Kumar and Kang (1998) and Luthra *et al.* (2005) in potato.

Table 3. Components of different clusters for marketable yield and its and its attributes in potato

Characters Cluster No.	Genotype Included (No.)	Plant height (cm)	Shoots plant^{-1} (No.)	Leaves plant^{-1} (No.)	Branches plant^{-1} (No.)	Compound Leaves /plant (No.)	Fresh weight of shoot plant^{-1} (g)	Dry weight of shoot plant^{-1} (g)	Fresh weight of tubers plant^{-1} (g)	Harvest Index (%)	Tuber plant- (No.)	Dry weight of tubers plant^{-1} (g)	Plant Emergence (%)	Un-marketable tuber yield (kg plot^{-1})	Marketable tuber yield (kg plot^{-1})	Total tuber yield tonnes (t/ha)
I	12	41.58	5.33	74.4	15.60	32.03	151.80	20.44	0.49	33.6	9.04	86.12	88.30	3.0	19.11	21.9
II	4	41.15	4.53	68.5	18.00	29.68	100.40	14.81	0.42	38.7	7.62	110.44	45.21	1.3	1.2	11.4
III	16	43.65	4.49	60.3	12.73	31.96	167.52	24.21	0.03	28.8	8.78	75.35	90.61	2.6	19.9	22.2
IV	10	41.68	4.59	68.6	16.56	29.71	136.32	18.26	0.39	29.5	9.35	62.62	75.77	3.3	13.3	15.8
V	2	42.98	4.97	84.2	14.17	33.34	121.01	16.10	0.54	40.9	11.56	104.1	95.39	5.7	26.4	32.8

All the genotypes included in present investigation, were indigenous, but their grouping in different clusters, suggested that genotypes did not follow the geographic distribution. Pandey and Gupta, (1997); Desai and Jaimini, (1997) also reported the agreement of above result in potato. This is not unexpected since there is a free exchange of materials for various breeding programme all over the world. Further, selection of material from same origin or source for different economic characters may be contributed to divergence. Gaur *et al.* (1978), in their study with 67 genotypes and Singh et al. (1988) with 40 genotypes also observed that clustering pattern was not influenced by geographic distribution of genotypes. Therefore, present findings suggest the existence of true genetic divergence in population of potato.

Based on the present findings on genetic divergence and its component analysis, it can be concluded that inter-crossing among the genotype of genetically diverse clusters showing superior mean performance may be helpful for obtaining desirable segregants with higher yield, hence in view of the above findings, genotypes namely J/93-86 and MS/95-1309 of cluster-V, J/95-227 and MS/92-3146 of cluster-I, Kufri Chipsona-3 of cluster-IV and MP/97-637 of cluster-II possessing superiority among genotypes may be utilized as parents in hybridization programme for obtaining desirable segregants and hybrids in potato.

Table 4. Desirable and diverse genotypes based on cluster performance

Character	Cluster-I	Cluster-II	Cluster-III	Cluster-IV	Cluster-V
1. Plant height (cm)	Kufri Badshah (50.84)	MP/97-637 (56.40 cm)	J/95-229 (56.09 cm)	MP/97-921 (52.40)	J/93-86 (46.13)
2. No. of shoots plant^{-1}	J/95-227 (7.72)	MP/97-625 (5.40)	Kufri Ashoka (7.51)	MP/97-644 (6.80)	J/93-86 (4.53)
3. Total No. ofleaves plant^{-1}	J/95-227 (86.78)	MP/97-637 (87.71)	J/92-148 83.13	MP/97-644 (79.33)	J/93-86 (84.50)
4. No. of branches plant^{-1}	Kufri Badshah (18.82)	MP/97-637 (23.87)	J/92-148 (20.80)	MP/97-644 (22.27)	J/93-86 (14.47)
5. No. of compound leaves plant^{-1}	MS/92-3146 (35.95)	J/93-139 (31.33)	Kufri Chandramukhi (35.60)	J/93-58 (31.20)	J/93-86 (33.73)
6. Fresh weight of shoot g plant^{-1}	MS/92-3146 (181.78)	J/93-139 (117.10)	Kufri Jawahar (89.42)	MP/97-921 (163.33)	MS/92-130~ (128.00)
7. Dry weight of shoots gplant^{-1}	J/92-159 (22.59)	MP/97-637 (16.42)	J/95-221 (28.08)	MS/91-1326 (21.48)	MS/92-1309 "(17.09)
8. Fresh weight of tubers g plant^{-1}	J/95-227 (0.57)	J/93-139 (0.47)	Kufri Pukhraj (0.520)	MP/97-644 (0.44)	J/93-86 (0.560)
9. Harvest Index (%)	MS/92-132 (397.81)	MP/90-83 (487.35)	J/95-229 (399.60)	Kufri Chipsona-3 (371.91)	J/93-86 (443.22)
10. No. of tubers plant^{-1}	MS/(2-209 (2.36)	MP/97-625 (8.73)	J/92-164 (11.91)	Kufri Chipsona-3 (14.60)	J/93-86 (12.12)
II. Dry weight of tubers (g plant^{-1})	MS/92-3146 (105.78)	J/93-139 (130.16)	J/98-159 (92 %)	B-420 (2) (88.1 I)	J/93-86 (128.34)
12. Percent Emergence (%)	Kufri Anand (97.97)	J/93-139 (55.74)	Kufri Pukhraj (100 %)	KMS/95-117 (87.76)	MS/92-1309 (96.67)
13. Unmarketable Yield (kg plot^{1})	JX-374 (0.57)	MP/97-625 (0.14 kg)	Kufri Chandramukhi (0.570 kg)	MP/97-921 (0.57 kg)	MS/92-1309 (1.93)
14. Marketable Yield (kg plot^{1})	J/95-227 (9.75)	J/93-139 (5.05)	Kufri Pukhraj (9.22)	J/93-58 (5.90)	MS/92-1309 (9.88)
15. Total Yield (kg plot^{1})	J/95-227 (9.53)	J/93-139 (5.54)	Kufri Pukhraj (10.60 kg)	J/93-58 (7.07)	J/93-86 (I 1.84)

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PHOSPHORUS AND SULPHUR MANAGEMENT IN MOTH BEAN [*VIGNA ACONITIFOLIA* (JACQ.) MARECHAL] UNDER RAINFED CONDITION

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ABSTRACT

A field experiment was conducted at SKN College of Agriculture, R.A.U., Jobner, Rajasthan during *kharif* season of 2004 to, see the effect of phosphorus and sulphur fertilizer on dry matter, number and weight of root nodules per plant, yield, yield components and nutrient content of mothbean under rainfed conditions. The results revealed that the increasing levels of phosphorus up to 30 kg P_2O_5 /ha significantly increased the dry matter accumulation per metre row length and number and dry weight of root nodules per plant as compared to preceding levels. Yield attributes, yield, nitroger, phosphorus and sulphur concentration in seed and straw as well as protein content in seed were increased significantly at 30 kg P_2O_5 /ha but it remained at par with 45 kg P_2O_5 /ha. Straw yield increased significantly up to 45 kg P_2O_5 /ha. In case of sulphur fertilization increasing levels of sulphur up to 30 kg /ha significantly increased the dry matter per metre row length, number of root nodules and their dry weight per plant. The number of seeds per pod and test weight increased significantly with the application of sulphur but significant increase with increasing levels of sulphur was recorded up to 20 kg /ha only. However, the number of pods per plant increased significantly with increasing levels of sulphur up to 30 kg /ha. Application of sulphur at 30 kg /ha significantly enhanced the seed and straw yield, nitrogen, phosphorus, sulphur in seed and straw, protein content in seed over preceding levels.

Key words : Moth bean, phosphorus, sulphur, rainfed.

In northern India, mothbean [*Vigna aconitifolia* (Jacq.) Marechal] is generally grown as a drought resistant *kharif* pulse crops in arid and semi-arid regions. Due to low and scanty rainfall, inadequate or even no use of fertilizers and cultivation on marginal or submarginal lands of poor feltility that results in its lower productivity. Phosphorus fertilization to legumes is more important than that of nitrogen because later is being fixed by symbiosis with Rhizobium bacteria, phosphorus is deficient in most soils of Rajasthan, particularly light textured ones where most of the moth bean is grown and amongst the various factors limiting the plant growth, phosphorus deficiency has been recognized as major bottleneck in realizing the potential yield of mothbean. Sulphur plays an important role in influencing the productivity of mothbean which help in many physiological processes of plant, development of root nodules and increase drought resistance in pulse by the process of disulphide linkage. Hence an experiment was conducted to evaluate the effect of phosphorus and sulphur fertilization on the performance of mothbean under rainfed conditions.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* seasons of 2004 at agronomy farm of the college, Jobner situated in semi arid eastern plain zone of Rajasthan. The soil was loamy sandy having pH 8.1, organic carbon 0.18%, low available nitrogen (130.2 kg/ha) and phosphorus (16.5 kg/ha) and medium available potassium (151.9 kg/ha). The experiment, comprised of four levels of each phosphorus (0, 15, 30 and 45 kg P_2O_5 ha^{-1}) and sulphur (0, 10, 20. and 30 kg S ha^{-1}) thereby making sixteen treatment combinations namely P_0S_0, $P_{15}S_0$, $P_{30}S_0$, $P_{45}S_0$, P_0S_{10}, $P_{15}S_{10}$, $P_{30}S_{10}$, $P_{45}S_{10}$, P_0S_{20}, $P_{15}S_{20}$, $P_{30}S_{20}$, $P_{45}S_{20}$, P_0S_{30}, $P_{15}S_{30}$, $P_{30}S_{30}$, $P_{40}S_{30}$ was laid out in randomized block design with 3 replications. The recommended dose of phosphorus was applied through DAP, drilled 10 cm deep at the time of sowing as per treatment. Sulphur was applied through gypsum containing 15 per cent sulphur before sowing as per treatment. A uniform dose of 20 kg/N ha was applied to all the plots by adjusting the N supplied by DAP and remaining through urea at the time of sowing. Moth bean variety 'RMO-40' was used as a test crop. The crop was evaluated in temlS of growth, yield attributes, yields and nutrients content.

Dry matter accumulation per metre row length was recorded at 20, 40 DAS and at harvest. For this, plants from one metre row length were uprooted randomly from sample rows of each plot. The number of root nodules per plant and dry weight of nodules per plant was counted and weighed at 40 DAS. Five plants were selected randomly in sample rows of each plot and uprooted carefully. In yield attributes plants randomly selected and were used for counting the number of pods per plant at harvest and their average was worked out to record pods' per plant. For number of seeds per pod, at the time of threshing, 10 pods were randomly selected from each plot and their total seeds were counted to record the average number of seeds per pod. The samples of seed and straw drawn at the time of threshing were used for N, P, S and protein determination.

RESULTS AND DISCUSSION

Phosphorus application significantly increased dry matter accumulation per metre row length at 30 kg P_2O_5 /ha being at par with 45 kg over control and 15 kg P_2O_5 /ha at all the stages of observation. Application of sulphur had significant effect on dry matter accumulation at all the stages of observation. Each higher level of sulphur in creased the dry matter over just preceding level significantly (Table 1). Application of sulphur @ 10, 20 and 30 kg /ha thus improved DM over control significantly. Both the number of nodules per plant and dry weight of root nodule per plant were differed significantly due to varying phosphorus and sulphur treatments. Phosphorus fertilization to mothbean increased the number of nodules per plant significantly up to 30 kg P_2O_5 /ha over control and 15 kg P_2O_5 /ha, respectively but remained at par with 45 kg P_2O_5 /ha. Similarly dry weight of root nodules/plant increased significantly up to 30 kg P_2O_5 /ha (Table 1). It might be obvious since phosphorus has long been considered as an essential constituent of all living organism which plays an important role in

Table 1. Influence of phosphorus and sulphur on dry matter accumulation per metre row length, number and dry weight of root nodules per plant

Treatments	Dry matter accumulation (g)			No.of root nodules/ plant	Dry weight of root nodules/ plant (mg)
	20DAS	40DAS	At harvest		
Phosphorus (kg/ha)					
0	11.7	24.6	81.0	10.70	57.33
15	13.9	32.2	98.6	12.40	64.58
30	15.5	35.5	103.9	13.48	69.58
45	15.9	36.1	107.6	13.53	71.92
S.Em+	0.3	0.5	1.4	0.19	0.95
CD at 5%	0.9	1.5	4.1	0.55	2.75
Sulphur (kg/ha)					
0	12.2	25.7	82.8	11.48	58.41
10	13.8	31.7	96.8	12.27	65.06
20	15.0	34.7	103.6	12.92	68.42
30	16.0	36.3	107.9	13.55	71.52
S.Em+	0.3	0.5	1.4	0.19	0.95
CD at 5%	0.9	1.5	4.1	0.55	2.75

conservation and transfer of energy in metabolic reactions of living cells including biological energy transformations (Chettri and Mondal, 2004). Phosphorus not only plays an important role in root development and proliferation but also improves nodulation and nitrogen fixation by supplying assimilates to the roots.

These results are in agreement with those of Sharma *et al.* (2002) and Yadav (2004) reported significantly in greengram higher dry matter accumulation, number and dry weight of nodules per plant due to phosphorus fertilization. Sulphur application resulted in significantly higher number of nodules per plant and dry weight of root/plant up to 30 kg S/ha (Table 1). Sulphur also help in development of nodules and nodulating bacteria. It is a part of nonheme Fe-S protein which help in various oxidation/ reduction processes in plants.

Application of graded levels of phosphorus up to 30 kg P_2O_5/ha significantly increased the number of pods per plant, number of seeds per pod and test weight over control and 15 kg P_2O_5 /ha, The higher crop growth with more supply of phosphorus might regulates starch/sucrose ratio in the source leaves and the reproductive organs (Giaqinta and Quebedeaux, 1980) have made available more photosynthates for formation of yield attributing parameters which consequently yielded more grain(Table 2). Similarly, each higher level of sulphur increased the number of pods per plant lover just preceding level significantly. Thus, application of 30 kg S ha -1 increased the number of pods per plant over control, 10 and 20 kg S/ha. Number of seeds per pod increased significantly with sulphur application up to 20 kg/ha but further increase in sulphur level did not increase the number of seeds per pod significantly. Similarly test weight incre'ased significantly due to application of graded levels of sulphur up to 20 kg/ha. Thus, application of 20 kg S/ha being at par with 30 kg S/ha (Table 2). Significant improvement in grain yield was recorded with increasing levels of phosphorus up to 30 kg/ha, while application beyond this level did not being significant improvement. When compared with seed yield of 7.84 and 9.31 q/ha recorded under control and 15 kg P_2O_5 /ha, application of 30 kg P_20_5 /ha enhanced the yield of seed by 2.06 and 0.59 q/ha, registering per cent increase of 26.28 and 6.34 respectively. Each increment in sulphur level significantly increased the seed yield of mothbean. When compared with seed yield of 8.08, 9.20 and 9.79 q/ha recorded under control, 10 and 20 kg S/ha, application of 30 kg S/ha enhanced seed yield by 2.11, 0.99 and 0.40 q/ha, registering per cent increase of 26.11, 10.76 and 4.09, respectively(Table 2). Straw yield was also affected by phosphorus and sulphur levels with increasing levels of phosphorus significantly increased the straw yield of moth bean. Application of phosphorus at 45 kg/ha recorded 28.42, 10.23 and 3.70 per cent more straw yield than control, IS, and 30 kg P_20_5/ha, respectively. There was also significant increase in straw yield of moth bean with increasing levels of sulphur up to 30 kg/ha (Table 2).

Nitrogen concentration in seed and straw as influenced by different phosphorus and sulphur treatments has been indicated in Table 2. Application of increasing levels of phosphorus up to 30 kg P_2O_5 /ha1 remaining at par with 45 kg/ha, increased the nitrogen concentration in seed as well as in straw of mothbean significantly as compared to 15 kg P_2O_5 /ha and control. Similarly application of sulphur increased the nitrogen concentration in seed and straw of moth bean but the increase was significant only up to 20 kg S/ha. Protein content in seed also increased significantly up to 30 kg P_2O_5/ha. Application of 20 kg S/ha significantly increased the crude protein content in seed over control and 10 kg S/ha by 8.70 and 3.76 per cent respectively(Table 2). Application of phosphorus might have improved the nutritional environment in rhizosphere as well as in the plant system, leading to increased uptake and translocation of nutrients especially of nitrogen, phosphorus and sulphur in reproductive structures which led to higher content and uptake (Ram and Dixit, 2001). Different levels of sulphur and phosphorus also effect the sulphur and phosphorus concentration in seed and straw. Phosphorus concentration in seed and straw of mothbean increased significantly with the

Table 2. Influence of phosphorus and sulphur on yield, attributes, seed and straw yield, nutrient content in seed and straw

Treatments	No.of pods/ plant	No.of seeds/ pod	Test weight (g)	Grain yield (q/ha)	Straw yield	N concentration (%)		Phosphorus (%)		Sulphur (%)		Protein
						Seed	Straw	Seed	Straw	Seed	Straw	
Phosphorus kg/ha												
0	18.85	4.38	25.57	7.84	17.45	3.266	1.645	0.372	0.218	0.338	0.154	20.41
15	24.55	4.74	26.90	9.31	20.33	3.579	1.903	0.430	0.264	0.360	0.167	22.37
30	27.27	5.03	27.98	9.90	21.61	3.683	2.023	0.476	0.273	0.369	0.177	23.02
45	28.65	5.18	28.30	10.22	22.41	3.685	2.063	0.485	0.278	0.373	0.182	23.03
S.Em+	0.50	0.09	0.33	0.12	0.25	0.034	0.024	0.005	0.003	0.003	0.002	0.22
CD at 5%	1.46	0.25	0.96	0.34	0.73	0.098	0.068	0.015	0.008	0.009	0.006	0.64
Sulphur (kg/ha)												
0	18.98	4.36	25.68	8.08	17.78	3.347	1.728	0.385	0.235	0.337	0.150	20.92
10	2367	4.76	26.85	9.20	20.26	3.506	1.889	0.441	0.258	0.357	0.169	21.91
20	27.05	5.01	27.94	9.79	21.40	3.638	1.992	0.462	0.268	0.369	0.178	22.74
30	28.60	5.20	28.33	10.19	22.37	3.722	2.026	0.475	0.272	0.375	0.183	23.26
SEm+	0.50	0.09	,0.33	0.12	0.25	0.034	0.024	0.005	0.003	0.003	0.002	0.22
CD at-5%	1.46	0.25	0.96	0.34	0.73	0.098	0.068	0.015	0.008	0.009	0.006	0.64

increasing levels of phosphorus up to 30 kg. Sulphur also increase phosphorus concentration in seed as well as in straw significantly with increase in sulphur levels up to 20 kg S/ha, but it remained at par with 30 kg S/ha. Increasing doses of phosphorus up to 30 kg recorded significantly higher sulphur concentration in seed and straw over their preceding levels(Table 2). There was also significant increase in sulphur concentration in seed as well as in straw with the successive increase in level attributes seems to be due to the supply of sulphur in adequate amount helps in the development of floral primordial i.e. reproductive parts, which results in the development of pods and seeds in plant (Ghanshyam and Pareek, 2002).

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GENETIC ADVANCE AND HERITABILITY STUDIES OF M_4 PROGENIES IN COWPEA (*VIGNA UNGUICULATA* L. WALP)

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Abstract

In the present investigation 117 M_4 progenies and 95 M_4 progenies derived from the genotypes RC-19 and RC-101, respectively, were evaluated during *kharif*-2005 to assess the extent of genetic variation for seed yield and its components at inter and intra-progeny level, to estimate genetic parameters of variation for seed yield and its components and to identify superior M_4 progenies for seed yield and its components. Analysis of variance revealed presence of significant amount of genetic variability at inter-progeny level for all the observed characters in the M4 progenies of both the genotypes. The intra-progeny variance was non-significant for all the observed characters in both the genotypes, except for seed yield per plant in the genotype RC-101. The range was wider in M_4 progenies than that of control for various observed characters in both the genotypes. In the M_4 progenies of both the genotypes high PCV and GCV were recorded for the branches per plant, pods per plant and seed yield per plant. Moderate heritability and high heritability for pods per plant was recorded in the M_4 progenies of the genotype RC-19 and RC-101, respectively along with high genetic advance as percentage of mean. The M_4 progenies revealed wider range, higher mean and higher CV values than that of control for most of the observed characters in both the genotypes. However, in some treatment groups the mean values were lower than the control means. Superior M_4 progenies for seed yield per plant along with other major seed yield components were identified in both the genotypes. Sodium Azide and EMS were revealed to be more effective in generating superior mutant progenies with multiple economic traits. In the M_4 progenies maximum numbers of progenies were superior with respect to mean as well as variance than the respective control for number of pods per plant in both the genotypes. The highest maximum increase in mean among the M4 progenies over the control mean was recorded for branches per plant in both the genotypes. In both the genotypes, the relative maximum increase for various characters was not similar. The results indicated that further improvement in M_4 progenies of both the genotypes was possible through selection for pods per plant at inter-progeny level. The superior M_4 progenies identified in the present investigation should be further evaluated in M_5 and M_6 generations, preferably over locations, in order to identify superior and stable progenies for seed yield per plant.

Key words : Cowpea, PCV, GCV, heritability, genetic advance, M_4 progenies.

Cowpea (*Vigna unguiculata* L. Walp) is an annual autogamous kharif pulse crop (Mackie and Smith, 1935). It has a chromosome number of 2n = 2 x = 22 (Frahm-Lelivied, 1965). Cowpea originated in Africa but exact place of domestication is uncertain (Ng and Marechal, 1985). India and China are considered to be the secondary centers of origin (Mishra *et al.*, 1985). Dry seeds of cowpea are known as "Vegetable meat" due to high amount of quality protein (23.4%), carbohydrate (60.3%), fat (1.8%), iron (57 mg/100 g), calcium (76 mg/100 g) and vitamins such as riboflavin (0.18 mg/100 g), nicotinic acid (1.9 mg/ 100g) and thiamin (0.92 mg/100g) (Chatterjee and Bhattacharya, 1986).

In any breeding programme adequate amount of genetic variability for major seed yield components is the foremost basic requirement. Genetic variability can be created either by hybridization or mutation. In cowpea, exploitation of recombinational variation through hybridization is limited due to high rate of flower abortion in that 70-75 per cent flowers are shed before anthesis and about half of remaining abort prematurely (Ojehomon, 1968). Moreover, the success of crosses is further reduced under rain-fed conditions due to lack of adequate moisture during flowering period. Thus, induced mutagenesis is important in order to generate genetic variability for major seed yield components.

MATERIALS AND METHODS

The material for the present investigation was consisted of M4 progenies of two cowpea genotypes, *viz.*, RC-19 and RC-101.These M4 progenies were derived by treating two genotypes of cowpea (*viz.*, RC-19 and RC-101) with 5 doses of the each of three mutagens (viz., Sodium Azide, EMS and Hydroxylamine) at the Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, Jobner. The M_1, M_2 and M_3 generations were sUbsequently evaluated during *kharif*-2002, *kharif*-2003 and *kharif*-2004, respectively. Out of the total M_3 progenies in each of the two genotypes, superior progenies with significantly higher mean alongwith higher or lower CV for seed yield per plant were selected. Out of these superior progenies individual superior M_3 plants were selected and harvested separately to get the seeds of M_4 progenies. Thus, in the present investigation 117 M4 progenies derived from the base material of RC-19 and 95 M_4 progenies derived from the base material of RC-101 were evaluated during *kharif*-2005.

In the present investigation the above 212 M_4 progenies alongwith the respective controls were evaluated during *kharif*-2005. The seed of these M_4 progenies were sown in 3 m long single row plots with the inter plant distance and row to row distance of 10 cm and 30 cm, respectively. The respective control was repeated after every 10 M_4 progenies for proper comparison. All the recommended agronomical and cultural practices were followed to raise a good crop.

Data was recorded on ten randomly selected competitive plants for quantitative characters *viz.*, Days to 50% flowering (days), Days to maturity (days), Plant height (cm), Number of branches per plant, Number of clusters per plant, Number of pods per plant, Pod length (cm), Number of seeds per pod, 100 seed weight (g) and Seed yield per plant (g) from each of the M_4 progenies and also in control. But the characters *viz.*, days to 50% flowering and days to maturity were recorded on plot basis.

The mean values of observation taken for various traits were used for determining genetic parameters. The methods used were those of Snedecor and Cochran (1967) for analysis of variance. Burton (1952) for genotypic and phenotypic variance and coefficient of variation. Heritability in broad was calculated as per Hanson *et al.* (1956) and genetic advance was computed as per standard method of Johnson *et al.*, (1955).

RESULTS AND DISCUSSION

The present investigation was conducted with the objectives to estimate the genetic variability present at inter and intra-progeny levels in the M4 progenies of two genotypes *viz.*, RC-19 and RC-101 and to identify superior M4 progenies. The material for the present investigation was consisted of 117 M4 progenies of the genotype RC-19 and 95 M4 progenies of the genotype RC-101 and the two genotypes RC-19 and RC-101. The experiment was carried out during *kharif*-2005. These M4 progenies were derived by treating two genotypes of cowpea (*viz.*, RC-19 and RC-101) with 5 doses of the each of the three mutagens *viz.*, Sodium Azide (0.3mM, OAmM, 0.5mM, 0.6mM and 0.7mM), EMS (0.15%,0.20%,0.25%,0.30% and 0.35%,) and Hydroxylamine (0.096%, 0.108%, 0.12%, 0.13% and 0.14%) at the Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, Jobner. The M_1, M_2 and M_3 generation were subsequently evaluated during *kharif*-2002, *kharif*-2003 and *kharif*-2004, respectively. Out of the total M_3 progenies in each of the two genotypes superior progenies with significantly higher mean along with higher or lower CV for seed yield per plant were selected. Out of these superior progenies individual superior M_3 plants were selected and harvested separately to get the seeds of M_4 progenies.

Thus, in the present investigation 117 M_4

progenies derived from the base material of RC-19 and 95 M_4 progenies derived from the base material of I RC-101 were evaluated along with the two genotypes RC-19 and RC-101 during *kharif*-2005.

The analysis of variance in M_4 progenies revealed presence of significant amount of genetic variability for all the observed characters at inter-progeny level in both the genotypes (Table 1). The intra-progeny variance was non-significant for all the observed characters in both the genotypes except for seed yield per plant in the genotype RC-101. The range was wider in M_4 progenies than that of control for various observed characters in both the genotypes. The estimate of phenotypic variance was higher than the respective genotypic variance for various observed characters in both the genotypes. Similarly, values of PCV were higher than GCV for all the observed characters in both the genotypes (Table 2). In M_4 progenies of both the genotypes high PCV and GCV were recorded for branches per plant, pods per plant and seed yield per plant. In the M_4 progenies of genotype RC-19, high genetic advance as percentage of mean along with moderate heritability was recorded for pods per plant while in M_4 progenies of genotype RC-101, high heritability along with high genetic advance as percentage of mean was recorded for pods per plant. Thus, selection for pods per plant at the inter-progeny level in the M_4 progenies of both the genotypes was seemed to be effective. The M_4 progenies revealed wider range of values than that of the control for various observed characters in both the genotypes. The means in the various treatment groups for various characters were mostly higher than the mean of the control in both the genotypes. However, in some treatment groups the mean values were lower than the control means. The CV in most of the treatment groups for most of the characters was higher than the CV of the control in both the genotypes.

There were number of M_4 progenies which exhibited superior mean values along with higher CV than that of respective control for most of the characters in both the genotypes. This indicated the possibility of isolating evens superior progenies through selection in M_4 generation.

The top twenty five M_4 progenies on the basis of mean seed yield per plant were identified in both the genotypes. These high yielding progenies were generally associated with higher mean values of pods per plant, number of cluster per plant, seeds per pod, plant height, number of branches per plant, pod length and 100 seed weight and also higher CV for seed yield per plant, pods per plant, pod length, seeds per pod and 100 seed weight. Out of these 25 best progenies for seed yield per plant in the genotype RC-19, 12 progenies resulted from EMS treatments while 8 resulted from Sodium Azide treatment and 5 from Hydroxylamine treatments. Similarly, in the genotype RC-101, 13 progenies resulted from Sodium Azide,

Table 1. Mean sum of squares of different quantitative characters in M_4 generation of cowpea genotype RC-19 & RC-101

Source of variation	d.f.	Plant height (cm)	Branches per plant	Clusters per plant	Pods per plant	Pod length (cm)	Seeds per pod	100 seed weight (g)	Seed yield per plant (g)
Between progenies	116	130.63**	0.90**	1.61**	52.32**	37.12**	46.44**	41.20**	12.00**
	(94)	(238.72**)	(1.30**)	(2.20**)	(66.61**)	(38.22**)	(49.81**)	(34.21**)	(22.51**)
Within progenies	1054	0.07	0.002	0.01	0.20	0.08	0.45	0.14	0.45
	(856)	(0.06)	(0.001)	(0.02)	(0.13)	(0.13)	(0.11)	(0.28)	(7.81 **)
Control	11	15.82	0.20	0.20	2.71	2.90	1.52	1.12	1.81
	(9)	(26.30)	(0.31)	(0.13)	(2.70)	(2.38)	(2.71)	(0.74)	(2.31)

** Significant at 1% level of significance

Value in parenthesis are genotypes RC-101

Table 2. Genetic parameters of variation for different characters in M_4 generation of cowpea genotype RC-19 & RC-101

Characters	Range			Variance		Coefficient of variation		Heritability in Broad sense (h2)	Genetic advance (as %of mean)
	Mean	Min.	Max.	Genotypic	Phenotypic	Genotypic	Phenotypic		
	(38.8)	(35.0)	(45.0)						
Days to maturity	55.5	50.0	59.0						
	(55.4)	(51.0)	(59.0)						
Plant height (cm)	17.9	13.2	27.2	13.1	28.9	20.2	30.0	45.2	27.9
	(15.1)	(8.6)	(32.0)	(23.9)	(50.2)	(32.3)	(46.9)	(47.6)	(46.0)
Branches per plant0.4	0.1	1.8	0.1	0.3	34.9	64.2	29.6	39.2	
	(0.53)	(0.1)	(1.8)	(0.1)	(0.4)	(37.4)	(65.6)	(32.6)	(44.0)
Clusters per plant	1.63	0.4	7.1	0.2	0.4	28.1	41.7	45.2	38.9
	(1.69)	(0.6)	(3.5)	(0.2)	(0.3)	(31.7)	(39.9)	(63.2)	(51.9)
Pods per plant	4.6	2.0	8.4	5.2	7.9	50.0	61.4	66.3	83.9
	(5.1)	(2.0)	(9.3)	(6.6)	)(9.3)	(50.6)	(599)	(71.4)	(88.1)
Pod length (cm)	9.5	6.7	12.0	3.7	$.6	20.2	26.9	56.1	31.1
	(Z.5)	(6.8)	(13.3)	(36)	(6.2)	(20.5)	(26.1)	(61.6)	(33.1)
Seeds per pod	8.3	4.3	11.6	4.6	6.1	25.8	29.8	75.2	46.2
	(8.0)	(5.3)	(12.4)	(5.0)	(7.6)	(28.0)	(34.7)	(65.1)	(46.5)
100 seed weight (g)	8.80	5.54	11.95	4.1	5.2	23.0	26.0	78.6	42.0
	(9.71)	(5.28)	(13.28)	(3.4)	(4.1)	(19.0)	(20.9)	(82.1)	(35.4)
Seed yield per plant (g)	2.1	0.7	4.1	1.2	3.0	51.2	82.2	38.8	65.7
	(2.5)	(0.8)	(9.8)	(1.5)	(3.8)	(48.3)	(77.7)	(38.6)	(61.7)

* Values in parenthesis are values of genotype RC-101

7 from EMS and 5 from Hydroxylamine. These results indicated that Sodium Azide and EMS were more effective in generating superior mutant progenies with multiple economic traits.

In the M_4 progenies of the genotype RC-19, maximum numbers of progenies were superior, with respect to mean as well as variance than the respective control, for number of pods per plant, followed by that for seed yield per plant and pods length. Similarly, in the M_4 progenies of RC-101, maximum numbers of M_4 progenies were superior for pods per plant followed by that for seeds per pod. The highest maximum increase in mean among the M_4 progenies over the control mean of the genotype RC-19 was recorded for branches per plant followed by pods per plant and seed yield per plant. Similarly, in the M_4 progenies of the genotype RC-101 the highest maximum increase in the mean was recorded for branches per plant followed by clusters per plant, pods per plant and seed yield per plant. Thus, in both the genotypes there was maximum improvement for branches per plant. In both the genotypes the relative maximum increase for various characters was not of similar magnitude. This may be due to the fact that both the genotypes differed greatly from each other in growth habit and other characters.

The results of the present investigation indicated that further improvement would be possible through selection for pods per plant at inter-progeny level in M_4 progenies of both the genotypes. The superior M_4 progenies identified in the present investigation should be further evaluated in M_5 and Me generations, preferably over locations, in order to identify superior and stable progenies for seed yield per plant.

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GENETIC VARIABILITY AND CORRELATION AMONG THE METHRIC TRAITS IN YELLOW SARSON (*BRASSICA RAPA* (L)VAR. YELLOW SARSON) GERMPLASM

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ABSTRACT

Fifty five accessions of yellow sarson were evaluated to study genetic variability and their correlation with seed yield. The material under study had sufficient genetic variability for most of the traits. The maximum variability was observed for secondary branches per plant followed by seed yield per plant. However, the least variability was observed for days to maturity followed by oil content. Accession MYSL 201 recorded high seed yield per plant, oil content and seeds per siliqua. Seed yield per plant showed positive and significant with primary and secondary branches per plant, siliquae on main shoot, siliqua length, harvest index, main shoot length, plant height, oil content and 1000 seed weight.

Key words : Accessions, genetic variability, siliqua, correlation, yellow sarson.

Rapeseed-mustard is an important group of crop plants with great economic value world wide. Oilseeds *Brassica* are the second most important source of edible oil after groundnut in the India. The *Brassica rapa* var yellow sarson commonly known as yellow sarson is one of the most important member of Brassicaceae family grown in India. This is grown since ancient time due to the presence of comparatively higher percentage of oil in the seed, shorter crop duration and attractive seed c oat colour. North-eastern India is considered as primary centre of origin, however genetic diversity found in eastern Uttar Pradesh and West Bengal. The improvement for yield and other traits not only depends upon the a mount 0 f variability present in the germ plasm but also on proper evaluation, ,further utilization in the breeding programmes. Germplasm provides the most valuable reservoir of variability on which direct selection can be made for evolving superior genotypes or it may be utilized as parent / donor in hybridization programmes. Hence, their is a need for proper evaluation and characterization of germ plasm resources. The exploitation of land races and wild relatives of crop plants to a larger extent depends upon the exploration and evaluation of natural populations. Evaluation and characterization of germ plasm is necessary to search useful donors in rapeseed-mustard (Chatterjee, 1992, Kumar *et al.*, 2004 and Kumar and Misra, 2007). The present study was under taken to find out variability parameters for 16 agro-morphological traits in respect of yellow sarson germ plasm augmented from different eco-geographical sources within the country.

MATERIALS AND METHODS

Fifty five accessions of yellow sarson were evaluated and characterized during two consecutive rabi season 04-05 and 05-06 in an augmented complete block design withthree checks (NDYS 2. RS 1 and YST 151) at the national Research centre on Rapeseed mustard, Bharatpur, Rajasthan, Each genotype was sown in paoired rows of 3m length with 30 x 10 cm spacing. Recommended standard agronomic package of practices and plant protection measures were adopted. Randomly tagged ten plants were selected at appropriate growth stages to record observations on morphological traits namely, initiation of flowering, 50% flowering, maturity, plant height, primary branches and secondary branches per plant, main shoot length, siliquae on main shoot, siliqua length, siliqua beak length and seeds per siliqua. Post harvest observations include seed yield per plant, 1000-seed weight, harvest index and quality traits (oil and protein content). The mean value for each character in each year were considered for computation, except for days to flower initiation, 50 % flowering and days to maturity (which was recorded on whole plot basis). One thousand seed were counted by electronic seed counter (Contador, Germany) and weighed bye lectronic balance. Oil and protein content were analyzed by Near Infrared Reflectance Spectroscopy (Dickey- John, Instalab 600). Replication wise data for each character were subjected for statistical analysis. Range, mean, coefficient of variation were computed using standard statistical methods by Gomez and Gomez (1984) and correlation coefficient were calculated according to the procedure of Singh and Chaudhary (1977).

RESULTS AND DISCUSSION

The material under study had sufficient genetic variability for most of the traits as indicated by the coefficient of variation (Table 1). The difference among germplasm was highly significant for most of the characters under study. Among the 16 traits studied, the maximum variability was observed for secondary branches per plant (CV 116.5%) followed by seed yield per plant (CV 73.5%). However, the least variability was observed for days to maturity (CV 1.5%) followed by oil content (CV 4.8%). Similar trends of genetic variations have also been reported in some of the earlier reports on oilseed Brassica (Yadav *et al.*, 1997; Kumar *et al.*, 2001; Misra *et al.*, 2004, 2005 and Patel and Patel 2005).

Promising donors identified on the basis of superiority over checks for various economic traits (Table 2), which can be utilized for future breeding programmes. Accession MYSL 201appeared to be a good source for seed yield per plant, oil content and seeds per siliqua. Accession PYS 9802 was observed as useful donor having oil content, harvest index and showing early maturity. Accession RAUDYS 9702 had early 50% flowering, maturity and also having high siliquae on main shoot.

Table 1. Range, mean and coefficient of variation (cv) for different agro-morphological traits in yellow sarson germplasm

Character	Range	Mean ± SEm	CV(%)		Checks	
				YST 151	NDYS 2	RS 1
Initiation of flowering	56.0-92.0	76.2 ± 1.2	11.3	54.0	68.0	63.0
50% flowering	65.0 - 97.0	89.1± 1.1	8.9	83.0	80.0	77.5
Primary branches	3.0 -11.2	6.2 ± 0.2	27.4	6.6	9.6	8.8
Secondary branches	2.5-12.0	2.5 ± 0.4	116.5	2.7	1.6	6.3
Seeds per siliqua	11.4 - 37.9	22.3± 0.8	25.3	15.6	36.3	13.1
Siliquae on main shoot	29.2 -78.6	44.2 ± 1.4	23.8	41.0	67.2	69.5
Days to maturity	132.0 - 140.0	136.4 ± 0.3	1.5	134.0	137.0	137.0
Plant height (cm)	53.2 - 151.4	100.0 ± 3.4	25.4	110.4	132.2	110.5
Main shoot length (cm)	25.6 - 63.8	45.2± 1.3	21.7	46.6	54.6	51.6
Siliqua length (cm)	3.5 - 5.2	4.2 ± 0.1	11.1	4.2	4.6	4.4
Siliqua beak length (cm)	1.1 - 2.6	1.7 ± 0.05	22.3	1.4	2.3	1.8
Seed weight (g)	2.3 - 5.1	3.4±0.1	19.0	3.0	3.4	2.7
Seed yield per plant (g)	1.1 - 23.4	6.4 ± 0.6	73.5	8.5	23.4	11.0
Harvest index (%)	14.3 - 35.8	23.9 ± 0.7	20.4	19.9	27.4	29.1
Protein content (%)	19.4 - 24.3	22.1 ± 0.2	5.1	20.5	21.5	21.2
Oil content (%)	36.5 - 45.8	41.0 ± 0.3	4.8	39.5	43.6	42.5

Table 2. Promising accessions of yellow sarson

Initiation of Flower	< 54.0 : NDYS 9504, SSK 9203, YSCN 14, RAUDYS 9702
50% Flowering	< 77.5: SSK 9203, YSCN 14, DYS 7
Maturity duration	< 134.0: RAUDYS 9702, PYS 9802, NIC 7172, IC147993
Plant height	< 110.4: IC 199735, IC 199738, IC 147993
Primary branches per plant	> 9.6: YSC 35, MYSL 209
Main shoot length	>54.6: YSC 5, IC 386314, YSC 35, YSPG 842
Siliquae on main shoot	> 69.5: RAUDYS 9702, YSCN 14
Siliqua length	> 4.6: NDYS 9, YSC 92, YSC 12, 18 1464
Seeds per siliqua	36.3: SSK 6, IC 199739, MYSL 201
Seed weight	>3.4: MYSL 209, SSK 9203, YSC 17, NDYS 9
Harvest index	> 29.1: PYS 9801, PYS 9802, SSK 9203, IC 147913
Seed yield per plant (g)	> 23.4: YSC 5, YSC 35, MYSL 201
Protein content (%)	> 21.5: IC 199743, NIC 1172, NDYS 9504, YSC 90
Oil content (%)	> 43.6: MYSL 201, PYS 9801, PYS 9802, IC 199741

To enhance the productivity of this crop under different production systems or to facilitate selection, correlation among the traits was worked out. Knowledge of relationship between yield and its components is essential as this may help in constructing suitable selection criteria for yield. Seed yield per plant had positive and significant correlation with primary and secondary branches per plant, siliquae on main shoot, siliqua length, harvest index, main shoot length, plant height, oil content and 1000-seed weight (Table 3). Whereas, seed yield per plant showed negative correlation with 50% flowering, initiation of flowering and protein content. This is conform ant of some of the earlier reports on yellow sarson (Kumar *et al.*, 2001, Katiyar *et al.*, 2004, Patel and Patel 2005 and Misra *el al.*, 2006).

Other yield contributed traits also showed positive and significant correlation namely 1000-seed weight with plant height, primary branches and secondary branches per plant, main shoot length, siliquae on main shoot and siliqua length; siliquae on main shoot with primary branches and secondary branches per plant, main shoot length and plant height; oil content with primary branches per plant, siliquae on main shoot and harvest index; siliqua length with plant height, primary branches per plant and main shoot length. Hence, suitable adjustment should be made at the time of selection for these characters. Similar trend of correlation were also observed in Indian mustard (Yadav *et al.*, 1997 and Misra *et al.*, 2006, 2007) and yellow sarson Misra *et al.*, (2006).

Table 3. Correlation between seed yield and its components traits in yellow sarson germplasm

Traits	#IF	FF	DM	PH	PB	SB	MSL	SMS	HI	SS	SL	SBL	SW	PC	OC
FF	0.764**														
DM	-0.025	-0.031													
PH	-0.218*	-0.292**	0.337**												
PB	-0.348**	-0.387**	0.125	0.694**											
SB	-0.421**	-0.496**	0.110	0.635**	0.624 **										
MSL	-0.272*	-0.410**	0.332**	0.849**	0.588**	0.634**									
SMS	-0.536**	-0.612**	0.034	0.577**	0.654**	0.558**	0.705**								
HI	-0.309**	-0.376**	-0.132	-0.029	0.150	0.030	0.061	0.305**							
SS	0.067	0.226*	0.193	-0.003	0.155	-0.224*	-0.170	-0.141	-0.078						
SL	0.088	0.074	0.172	0.580**	0.405**	0.172	0.435**	0.201	-0.070	0.155					
SBL	0.113	0.086	0.471**	0.090	0.148	-0.157	0.020	-0.021	-0.057	0.415**	0.283**				
SW	-0.344**	-0.465**	0.050	0.485**	0.418**	0.579**	0.467**	0.315**	0.105	-0.172	0.268*	-0.047			
PC	0.342**	0.404**	0.187	-0.002	-0.210	-0.070	-0.065	-0.220*	-0.369**	-0.110	-0.043	-0.079	-0.086		
OC	-0.367**	-0.532**	-0.191	0.014	0.232*	0.094	0.067	0.272*	0.473**	0.132	-0.016	0.068	0.174	-0.833**	
SYP	-0.386**	-0.475**	0.183	0.552**	0.745**	0.532**	0.594**	0.601**	0.312**	0.153	0.286**	0.091	0.418**	0.386**	0.525*

* I ** Significant at 5 and 1 % respectively

#IF: Initiation of flowering, FF: 50% flowering, PB: Primary branches per plant, SB: Secondary branches per plant. MSL: Main shoot length. PH: Plant height, SMS: Siliquae on main shoot, DM: Maturity duration, SBL: Siliqua beak length, SL: Siliqua length, SYP: Seed yield per plant (g), SS: Seeds per siliqua, HI: Harvest index, SW: Seed weight. PC: Protein content and OC: Oil content

When the variability, correlation are considered together the present accessions proved to be an important gene pool for different traits and many accessions can be utilized for breeding programmes to develop suitable varities for different agro climatic conditions and also to improve yield and quality.

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EFFECT OF BALANCED FERTILIZATION, WEED CONTROL AND SOWING METHODS ON PRODUCTIVITY AND QUALITY OF DURUM WHEAT (*TRITICUM DURUM* DESF.)

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ABSTRACT

A field experiment was conducted during the winter seasons of 2003-04 and 2004-05 to study the effect of balanced fertilization, herbicidal weed control and sowing methods on productivity and quality of durum wheat (*Triticum durum* Desf.). Application of S, Zn and S+Zn along with primary nutrients (NPK) significantly increased plant height, dry matter accumulation, grain, straw and biological yields of durum wheat crop over NPK alone. Conjoint application of NPK+S+Zn also enhanced the quality of durum wheat grain by increasing the hectoliter weight, protein content, beta-carotene content and sedimentation value and reduced the yellow berry incidence. The highest yield was recorded with soil enrichment by 120 kg N + 40 kg P_2O_5 + 30 kg K_2O + 50 kg S + 5 kg Zn/ha which was significantly higher over rest of the fertilizer treatments. Use of herbicides (2,4-D 0.5 kg and metsulfuron methyl 4 g/ha 30 DAS) resulted in significantly higher crop dry matter accumulation, grain, straw and biological yields over weedy check. Both these herbicides improved the grain quality by increasing hectoliter weight, protein content, beta-carotene content and sedimentation value and reduced the prevalence of yellow berry. Cross sowing at 23cm x 23cm recorded significantly higher crop dry matter, grain, straw and biological yields than normal line sowing of 23 cm. The grain quality was not affected by sowing methods.

Key words : Durum wheat, balanced fertilization, herbicides, sowing methods, yield, quality.

Among different wheat species, durum is next in importance to aestivum. It is highly valued for making semoline (suji) and vermicelli. In western countries, durum wheat is mainly consumed as pasta products. An increasing global demand, value addition potential, resistance to disease, better market price are some key factors which make Indian durum wheat an export commodity. Exploitive agriculture making use of high analysis NPK fertilizers like urea, diammonium phosphate and murate of potash has depleted the soils of their secondary and micronutrient reserves. Therefore, the balanced use of fertilizer is essential for increasing productivity (Sharma and Manohar, 2002). Sulphur performs many physiological functions like synthesis of sulphur containing amino acids which have a positive role in improving growth of plants. Zinc plays significant role in enzymatic and physiological activities of plant body. Both sulphur and zinc are now considered important elements besides NPK to balance nutrient application to field crop. Weeds have been recognized as a serious menace in crop production. In general, season long presence of weeds in wheat results in yield reduction to the tune of 15-40 per cent and sometimes even higher (Malik *et al.*, 1989). Weed control cost is a major segment of input cost in crop production and herbicides provide a better opportunity to control weeds in close row crops like wheat where manual or mechanical weeding is not possible (Yaduraju and Mishra, 2002). The maintenance of optimum plant stand with the use of optimum seed rate and appropriate sowing method is of prime importance for exploiting available resources (below and above ground) towards yield formation. Even distribution of plants under cross sowing facilitates greater availability of growth inputs with least intra and inter plant competition which consequently results in realization of higher productivity of wheat (Kumpawat, 1998). Therefore, the present experiment was conducted to assess effect of balanced fertilization, weed control and sowing methods on productivity and quality of durum wheat (*Triticum durum* Desf.).

MATERIALS AND METHODS

The investigation was carried out during winter seasons of 2003-04 and 2004- 05 at Krishi Vigyan Kendra, Kota. The soil was clay loam in texture, medium in organic carbon (0.7%), available nitrogen (257.0 kg/ha), phosphorus (15.8 kg/ha) and high in potassium (470 kg/ha), while, low in sulphur (8.1 mg/kg soil) and zinc (0.71 mg/kg soil). It was slightly alkaline in pH (7.9). The experiment was laid out in split plot design, comprising two sowing methods (normal line sowing at 23 cm and cross sowing at 23cm x 23cm), three weed control treatments (weedy check, 2,4-D 0.5 kglha and metsulfuron methyl 4.0 glha post emergence 30 DAS) in main plots and four nutrient combinations (NPK 120 + 40 + 30 kglha, NPK + S 50 kg/ha, NPK + Zn 5 kglha and NPK + S + Zn) in sub plots. It was replicated thrice. Durum wheat cv. HI 8498 was sown on 25th November 2003 and 2nd December 2004. Crop was fertilized as per treatments. Full dose of phosphorus, potassium, sulphur, zinc and half dose of nitrogen were drilled in furrows at the time of sowing. The remaining nitrogen was top dressed first irrigation. Herbicides were sprayed as post emergence (30 days after sowing) as per treatments, with the help of knapsack sprayer fitted with flat fan nozzle using 600 liter waterlha. The crop was grown with all recommended packages of practices except the treatments under investigation.

RESULTS AND DISCUSSION

Growth and yield

Crop fertilized with NPK + S, NPK + Zn and NPK + S + Zn recorded significantly higher plant height at harvest and dry matter accumulation at 50 and 75 DAS in comparison to NPK alone (Table 1). Although, maximum plant height and dry matter were observed with application of S + Zn in addition to NPK which were statistically at par with NPK + S and NPK + Zn. Soil enrichment with above mentioned nutrient combinations produced significantly higher grain, straw and biological yields than NPK alone. However, the highest yields were registered with application of NPK + S + Zn which was significantly higher over rest of the nutrient combination. Increase in grain yield to the tune of 16.0, 12.7 and 20.8% during 20032004 and 12.3, 11.0 and 18.4% during 2004-2005, respectively were recorded with application of NPK + S, NPK + Zn and NPK + S + Zn over NPK alone. Similar findings were recorded by Islam *et al.* (2002). It is well emphasized that balanced nutrition markedly improved overall growth of the crop by virtue of its impact on morphological and photosynthetic components along with accumulation of nutrients. This provided opportunity for availability of nutrients and metabolites for growth and development sink, which ultimately resulted in realization of higher productivity of crop.

Dry matter accumulation of wheat at 50 and 75 DAS was increased significantly by herbicidal weed control treatments over the weedy check (Table 1). However, plant height was not affected significantly by controlling weeds. It is evident from the data (Table 1) that metsulfuron methyl produced higher crop dry matter and yield and followed by 2,4-D. The two herbicides under study were at par in producing grain yield of durum wheat across the years. Increase to tune of 10.5 and 13.7% during 2003-04 and 8.9 and 11.4% during 2004-05 were registered by controlling weeds through 2,4-D and metsulfaron methyl, respectively. The straw and biological yield produced under the effect of both these herbicides were at par but significantly higher over weedy check. The increase in dry matter and yield of wheat due to herbicidal weed control can be clearly attributed to the reduction in interference of the weeds which ultimately favoured better growth environment for the crop and thus gave higher yield of wheat. The improvement in yield with these herbicides were also reported by Singh and Singh (2005).

Cross sowing recorded significantly higher biomass production at 50 and 75 DAS over normal line sowing (Table 1). However plant height did not differ significantly on account of sowing methods. Cross sowing gave higher grain yield by 15.6% during 2003-04 and 10.0% during 2004-05 over normal line sowing. Pandey and Kumar (2005) also reported the similar results. Higher yield under cross sowing was due to

Table 1. Effect of balanced fertilization, weed control and sowing methods on growth and yields of durum wheat

Treatments	Plant height (cm)		Dry mater (q/ha)				Grain yield (q/ha)		Straw yield (q/ha)		Biological yield (q/ha)	
			50DAS		75DAS							
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Fertilization												
NPK	84.00	86.61	16.20	13.75	65.86	64.61	39.38	39.13	50.85	50.57	90.23	89.71
NPK+S	89.66	91.16	17.44	15.39	70.69	69.63	45.68	43.88	55.58	54.88	101.27	98.77
NPK+Zn	89.33	91.16	17.18	15.08	69.48	68.51	44.34	43.38	54.00	52.98	98.34	96.36
NPK+S+Zn	91.61	92.22	17.72	15.65	71.00	69.94	47.57	46.29	57.99	57.74	105.57	104.04
S.Em±	0.85	0.69	0.25	0.40	1.17	0.90	0.58	0.61	0.71	0.82	0.97	1.16
CD (P = 0.05)	2.43	2.00	0.73	1.16	3.37	2.59	1.67	1.75	2.05	2.36	2.79	3.35
Weed control												
Weedy check	88.54	90.00	16.00	13.52	66.25	65.19	40.93	40.43	51.27	51.68	92.21	92.12
2,4-0	88.79	90.00	17.62	15.65	70.51	69.36	45.26	44.04	55.54	54.69	100.80	98.74
Metsulfuron methyl	88.62	90.87	17.77	15.74	71.01	69.97	46.54	45.03	57.01	55.76	103.55	100.79
S.Em±	1.15	0.66	0.24	0.37	1.01	1.05	0.93	0.66	0.67	0.95	1.45	1.07
CD (P = 0.05)	N.S.	N.S.	0.77	1.17	3.21	3.32	2.93	2.10	2.11	3.00	4.58	3.38
Sowing methods												
Line sowing	88.27	90.11	16.49	13.99	67.47	66.49	41.03	41.16	51.90	52.58	92.94	93.74
Cross sowing	89.02	90.47	17.78	15.94	71.05	69.85	47.45	45.18	57.31	55.51	104.77	100.70
S.Em±	0.94	0.53	0.20	0.30	0.83	0.86	0.76	0.54	0.54	0.77	1.18	0.87
CD (P = 0.05)	N.S.	N.S.	0.63	0.96	2.62	2.71	2.39	1.71	1.72	2.45	3.73	2.76

Table 2. Effect of balanced fertilization, weed control and sowing methods on quality parameters of durum wheat

Treatments	Hectolitre weight (kg/hL)		Protein content (%)		Beta-carotene content (ppm)		Yellow berry (%)		Sedimentation value	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Fertilization										
NPK	80.21	80.62	13.66	13.32	4.50	4.51	9.22	9.83	30.61	31.27
NPK+S	81.39	81.32	14.56	14.55	4.80	4.81	5.94	6.44	31.77	32.38
NPK+Zn	81.27	81.39	14.26	14.31	4.61	4.65	6.83	6.83	31.77	32.11
NPK+S+Zn	82.10	81.66	14.70	14.64	4.86	4.85	4.33	4.44	32.38	32.77
S.Em±	0.20	0.20	0.09	0.12	0.02	0.02	0.26	0.26	0.33	0.34
CD (P = 0.05)	0.60	0.59	0.26	0.34	0.07	0.07	0.76	0.77	0.96	0.99
Weed control										
Weedy check	80.67	81.26	13.74	13.56	4.65	4.65	7.58	7.62	31.04	31.83
2,4-D	81.52	81.23	14.59	14.52	4.71	4.73	6.04	6.54	32.12	32.25
Metsulfuron methyl	81.54	81.26	14.56	14.53	4.72	4.73	6.12	6.50	31.75	32.33
S.Em±	0.21	0.20	0.08	0.11	0.02	0.02	0.30	0.29	0.23	0.17
CD (P = 0.05)	0.68	N.S.	0.28	0.35	N.S.	0.06	0.96	0.93	0.74	N.S.
Sowing methods										
Line sowing	81.17	81.30	14.28	14.14	4.68	4.69	6.97	7.05	31.55	32.05
Cross sowing	81.32	81.20	14.31	14.27	4.71	4.72	6.19	6.72	31.72	32.22
S.Em±	0.17	0.16	0.07	0.09	0.01	0.01	0.25	0.24	0.19	0.14
CD (P = 0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

better crop canopy development which resulted in more efficient utilization of solar radiation and nutrient by the crop.

Quality

Soil enrichment with NPK +S, NPK +Zn and NPK +S+Zn significantly enhanced quality parameters of durum wheat *viz.*, hectoliter weight, protein content, beta-carotene content, sedimentation value and reduced yellow berry incidence in grain than NPK alone. The maximum values of quality of grain was observed with application of NPK +S+Zn (Table 2). Similar findings were recorded by Islam *et al.* (2002).

The improvement in quality of durum wheat was also observed by weed control through herbicides. On an average, the increases in protein content, were 6.6 and 6.5%, in beta-carotene content 1.5 and 1.5%, in sedimentation values 2.4 and 1.94% under 2,4-D and metsulfuron methyl, respectively over weedy check. The higher protein content in wheat grain due to application of herbicide was also reported by Pandey and Kumar (2005). The higher protein content in weed control treatments might be due to increased uptake of nutrients by the crop plants.

The grain quality of durum wheat was not affected by sowing methods during both the years of study.

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PERFORMANCE OF PIGEONPEA (*CAJANUS CAJAN*) AS INFLUENCED BY INTERCROPPING WITH BLACKGRAM (*VIGNA MUNGO*), PHOSPHORUS NUTRITION AND BIO-FERTILIZERS

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ABSTRACT

A field experiment was carried out during *kharif* 2003 and 2004 at the farm of the Amar Singh Post Graduate College, Lakhaoti to study the impact of intercropping, phosphorus nutrition and bio-fertilizers on the performance of pigeonpea. The treatments consisted of combinations of 2 cropping systems viz. sole pigeonpea and pigeonpea + blackgram in 1:1 ratio; 3 levels of phosphorus viz. 0, 30 and 60 kg P_2O_5 /ha and 3 levels of bio-fertilizers viz. control, *Rhizobium* and *Rhizobium* + phosphate solubilizing bacteria (PSB) was canductd in factorial randomized block design replicated thrice. The results indicated that the growth and yield parameters were superior in sole pigeonpea as compared to intercropping with blackgram. The increasing levels of phosphorus and combination of *Rhizobium* + PSB significantly improved all the growth and ntercropping, Phosphorus, Pigeonpea.

Key words : Bio-fertilizers, blackgram, economics, intercropping, phosphorus, pigeonpea.

Pigeonpea is one of the leading *kharif* pulse crops grown in India. It occupies an area of 3.58 m ha with a production of 2.74 m tonnes of seeds at an average productivity of 765 kg/ha (DES, 2007). It is also cultivated in Uttar Pradesh under many agro-ecological conditions. However it is mostly grown in areas with limited irrigation availability. Often due to its low productivity and uneconomic nature it is mostly grown as intercropping with other crops like maize, jowar, bajra etc. Growing of short duration intercrops like blackgram and greengram holds great promise as they are morphologically different and come to harvest at different points of time avoiding competing for the growth factors. Further being a legume, it responds to application of phosphorus and bio-fertilizers like *Rhizobium* and phosphate solubilizing bacteria (PSB). This experiment was carried out to examine the performance of pigeonpea grown in sole and intercropping with blackgram under varied levels of phosphorus and bio-fertilizers.

MATERIALS AND METHODS

Field experiments were conducted at the Agronomy Research Farm, Amar Singh College, Lakhaoti, and Bulandshahr (U.P.) during *kharif* season of 2003 and 2004. The soil of the experimental field was sandy loam in texture, well drained and of medium fertility and slightly alkaline in reaction (pH 7.5). It was low in organic carbon (0.39%), medium in phosphorous (10.56 kg/ha) and high in potassium (186 kg/ha) content. The climate during the experimental period during both the years of experimentation was normal with no inclement weather.

The treatments comprised of two cropping systems viz. sole pigeonpea and pigeonpea + blackgram in 1:1 ratio under additive series, three phosphorus levels viz. 0, 30 and 60 kg P_2O_5 /ha and three bio-fertilizers viz. untreated control, seed treatment with *Rhizobium* alone and combined inoculation of *Rhizobium* and phosphate solubilizing bacteria (PSB). These were tried in factorial randomized block design replicated thrice. Pigeonpea var. 'Pusa 33' and blackgram var. 'Type 9' were used as test crops. The pigeonpea was sown in 50 cm rows using a seed rate of 20 kg/ha while blackgram was sown between two rows of pigeonpea.The phosphorus in the form single super phosphate as per the treatments and urea at the rate 20 kg/ha uniformly were applied as basal before sowing. The seeds of pigeonpea were treated with appropriate strains of *Rhizobium* and PSB before sowing. Gap filling and thinning excess plants was done 10 days after sowing on emergence of seedlings. All the important growth parameters at harvest and nodulation studies at 75 days stage were done and statistically analyzed as per the analysis of variance technique for factorial randomized block design. The economics for the crops were worked out using the prevailing market rates for both the inputs and the produce.

RESULTS AND DISCUSSION

Growth attributes

Sole pigeonpea recorded significantly higher plant height, drymatter accumulation, nodule number and their biomass as compared to pigeonpea intercropped with blackgram (Table 1). The branches per plant were however not influenced by the intercropping. This may be attributed to the competition between pigeonpea and blackgram for growth factors like space, water, nutrients and radiation. The increasing levels of phosphorus too increased the plant height, branches per plant, drymatter accumulation, nodules and their biomass in pigeonpea. The significant increase in plant height and branches/plant, upto 30 kg P_2O_5/ha while other parameters increased upto 60 kg P_2O_5/ha. This clearly indicated that there is a need for higher doses of phosphorus in pigeonpea for better growth and development. The seed treatment with *Rhizobium* and phosphate solubilizing bacteria (PSB) enhanced all the growth attributes as compared to *Rhizobium* alone or control. It clearly indicated that seed inoculation with both of these is necessary for realizing maximum growth as they are effective in enhancing the availability of nitrogen and phosphorus, respectively to the crop.

Table 1. Groth and nodulation parameters in pigeonpea as influenced by cropping systems, phosphorus levels and bio-fertilizers

Treatment	Plant height (cm)		Branches/ plant		Drymatter (g/plant)		Nodules/ plant		Nodule biomass (mg/plant)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Cropping system										
Sole pigeonpea	149.1	140.1	15.7	14.9	51.3	46.5	16.0	16.6	144.2	162.7
Pigeonpea + blackgram	138.5	128.0	15.6	13.0	42.6	37.8	13.4	14.7	129.4	153.3
SEm+	2.2	2.8	0.2	0.2	0.9	0.9	0.2	0.2	3.2	3.2
CD (P=0.05)	6.9	8.8	NS	NS	2.9	3.0	0.4	0.6	9.3	9.2
Phosphorus levels (kg P_2O_5/ha)										
0	133.5	123.3	14.5	12.7	38.8	33.9	12.3	13.5	121.1	132.5
30	146.7	136.7	16.0	14.3	48.7	43.9	14.2	15.4	131.9	167.1
60	151.1	142.2	16.5	14.8	53.5	48.7	17.5	18.1	157.4	174.5
SEm+	2.2	2.7	0.2	0.3	0.9	1.0	0.1	0.2	2.6	2.6
CD (P=0.05)	6.2	7.9	0.7	0.8	2.7	2.8	0.4	0.5	7.6	7.5
Biofertilizer										
Control	126.1	117.2	12.4	10.7	31.1	26.3	12.4	12.6	109.7	121.4
Rhizobium	149.1	139.1	16.6	14.8	51.2	46.5	14.8	15.2	128.3	155.0
Rhizobium + PSB	156.2	145.9	18.1	16.3	58.7	53.7	16.8	19.2	172.5	197.6
SEm+	2.7	3.1	0.2	0.3	1.1	1.2	0.3	0.1	3.4	3.7
CD (P=0.05)	8.4	10.8	0.8	0.9	3.5	3.6	1.3	0.5	13.4	14.4

Yield attributes

The cropping systems did not have much influence on the yield parameters except for number of pods/plant in 2003 and pod length in 2004 (Table 2). This may attributed to the fact that the early harvest of blackgram did reduced the competition for the pigeonpea in later part of the reproductive phase. However the intercropping of blackgram recorded lower values of all the yield parameters as compared to sole pigeonpea. The phosphorus levels too had significant impact on the yield attributes. Application of 60 kg P_2O_5/ha recorded significantly higher pods/plant, while the 30 kg P_2O_5/ha recorded significantly higher pod length, number of seeds/pod and test weight. This further is consequence higher need of phosphorus for the crop, which recorded higher growth attributes and later the yield parameters. The yield parameters were significantly higher with seed inoculation with *Rhizobium* alone and *Rhizobium* and phosphate solubilizing bacteria (PSB) as compared to untreated control. This clearly showed the importance of bio-fertilizers for realizing the better growth and yield parameters.

Yield and economics

Pigeonpea recorded significantly higher seed yield when grown as sole crop as compared to intercropping with blackgram (Table 3). The stover yield also showed the similar trend. Similar results were also observed by Adhikary and Sarkar (2000). This may be attributed to better growth and yield attributes due unhindered crop in sole cropping system., while the intercropping impeded pigeonpea growth through competition as shown by reduced growth and yield attributes. The harvest index was influenced by the cropping systems. The net returns and B:C ratio were higher in pigeonpea intercropped with blackgram. This is mainly due to contribution of blackgram to total seed yield resulting in increased net returns and there by

Table 2. Yield attributes of pigeonpea as influenced by cropping systems, phosphorus levels and bio-fertilizers

Treatment	No. of pods/plant		Pod length (cm)		No. of seeds/pod		Test weight (g)	
	2003	2004	2003	2004	2003	2004	2003	2004
Cropping system								
Sole pigeonpea	49.5	46.4	4.5	4.3	4.7	4.5	71.5	68.6
Pigeonpea + blackgram	47.6	44.5	4.5	3.9	4.7	4.4	70.1	67.2
SEm+	0.6	0.6	0.1	0.1	0.1	0.1	0.9	0.9
CD (P=0.05)	1.8	NS	NS	0.3	NS	NS	NS	NS
Phosphorus levels (kg P_2O_5/ha)								
0	41.4	38.8	4.3	3.8	4.6	4.4	67.6	64.6
30	50.2	46.1	4.6	4.2	4.8	4.5	71.9	68.9
60	54.0	51.6	4.7	4.3	4.8	4.6	73.1	70.2
SEm+	0.6	0.6	0.1	0.1	0.1	0.1	0.8	0.9
CD (P=0.05)	1.8	1.8	0.3	0.3	0.1	NS	2.4	2.6
Biofertilizer								
Control	40.2	38.0	4.0	3.7	4.3	4.1	67.5	64.6
Rhizobium	50.5	47.8	4.7	4.4	4.8	4.6	71.9	68.8
Rhizobium + PSB	54.9	50.6	5.0	4.2	5.1	4.8	73.1	70.3
SEm+	0.7	0.8	0.1	0.1	0.1	0.1	1.0	1.1
CD (P=0.05)	2.2	2.4	0.4	0.4	0.2	0.3	3.3	3.6

Table 3. Grain yield, stover yield and harvest index of pigeonpea as influenced by cropping systems, phosphorus levels and bio-fertilizers

Treatment	Seed yield (kg/ha)		Stover yield (kg/ha)		Harvest index (%)		Net returns (Rs/ha)		B:C ratio	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Cropping system										
Sole pigeonpea	1.190	1.100	4.89	4.65	24.0	23.3	17,249	14,870	1.60	1.38
Pigeonpea + blackgram	1.085	0.976	4.57	4.21	23.6	23.1	19,489	17,164	1.80	1.58
SEm+	0.015	0.017	0.10	0.09	0.6	0.5	331	413	0.01	0.02
CD (P=0.05)	0.053	0.059	0.31	0.28	NS	NS	1008	1251	0.03	0.07
Phosphorus levels (kg P_2O_5/ha)										
0	0.944	0.809	4.16	3.96	22.4	20.7	13,621	10,885	1.37	1.10
30	1.203	1.114	4.90	4.59	24.5	24.3	20,090	17,970	1.83	1.63
60	1.267	1.192	5.13	4.75	24.6	24.6	21,397	19,196	1.86	1.66
SEm+	0.015	0.018	0.10	0.09	54.0	0.5	404	398	0.02	0.01
CD (P=0.05)	0.047	0.053	0.28	0.25	1.6	1.3	1252	1201	0.06	0.04
Biofertilizer										
Control	0.891	0.788	3.99	3.55	22.2	22.0	16,323	14,724	1.59	1.43
Rhizobium	1.219	1.119	4.98	4.73	24.4	23.6	18,713	16,176	1.71	1.48
Rhizobium + PSB	1.305	1.206	5.22	5.02	24.8	24.0	20,073	17,150	1.79	1.53
SEm+	0.019	0.021	0.12	0.11	0.7	0.6	511	308	0.02	0.01
CD (P=0.05)	0.067	0.073	0.38	0.34	2.1	NS	1567	942	0.06	0.03

increase B:C ratio. Similar increase in monetary returns due to intercropping was also reported by Singh (2000). The phosphorus levels too recorded significant increase in the seed and stover yield. The seed yield increase upto 60kg P_2O_5/ha while the stover yield increased upto 30 kg P_2O_5/ha. The harvest index was increased significantly upto 30 kg P_2O_5/ha , the net returns and B:C too were increased significantly upto 30 kg P_2O_5/ha only. Singh and Chaudhary (1992) also observed increased growth and yield parameters followed by increased seed and monetary returns due to phosphorus nutrition. The bio-fertilizers too had significant influence on the seed and stover yield, harvest index, net returns and B:C ratio. Both *Rhizobium* alone or in combination with phosphate solubilizing bacteria (PSB) showed higher values as compared to untreated control. Such positive effect of combined application of *Rhizobium* and phosphate solubilizing bacteria (PSB) have also reported by Chandra and Pareek (2002). This may be attributed to their positive influence on the growth and yield attributes and subsequent increase in yield and monetary returns.

On the basis of this 2 years field study it may be concluded that growing of pigeonpea intercropped with blackgram providing 60 kg P_2O_5/ha as basal application and seed inoculation with *Rhizobium* and phosphate solubilizing bacteria (PSB) results in higher yield and monetary returns.

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GENETIC ANALYSIS OF ECONOMIC CHARACTERS IN INDIAN MUSTARD [*BRASSICA JUNCEA* (L.) CZERN & COSS]

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Abstract

Consistency of the results of diallel F_2 analysis in relation to results of diallel F_1 analysis for economic traits in mustard (*Brassica juncea* (L.) Czern &Coss) was studied to assess their comparative effectiveness and appropriate breeding strategy. The size of the diallel was 9 x 9 planned for the purpose and experimentation years were 2003-2004 and 2004-2005. The diallel F_2 analysis emerged as the more comprehensive and useful method for understanding the nature and magnitude of genetic variances as well as combining ability variances and effects governing expression of quantitative traits. It was evident from the two analysis that additive and non-additive genetic variances are important in controlling seed yield, its contributing traits and oil content in this crop. However, the relative magnitude of non-additive component was higher than additive for all the characters studied in both the generations except days to flower in F_1 only.

Key words : Indian mustard, *Brassica juncea*, diallel, additive, dominant, GCA, SCA.

Diallel analysis has been widely used not only for understanding the gene effects both in cross-and self-pollinated crops but also deciphering the general and specific combining ability variances and effects in parents used and hybrids generated. Diallel cross with small number of parents give poor estimates of genetic parameters because of large sampling error. However, a full diallel set becomes unmanageable with increase in the number of parents. (Griffing, 1956 and Curnow, 1963). It is not always possible to produce enough F_1 seeds particularly in self-pollinated crops, such as mustard as required for appropriate experimentation. In such cases, diallel analysis can be usefully carried out using F_2 data. Voluminous literature is available on the use of diallel in different autogamous crops. However, little work has been done on comparative effectiveness of diallel F_1 and F_2 analysis, particularly in mustard. Therefore, the present study was carried out to discuss both gene effects and combining ability for seed yield and its components through F_1 and F_2 diallel analysis.

Materials and Methods

The experimental material consisted of diallel set excluding reciprocals of nine variety/ strains *viz.*, T-59, RH-30, Pusa Bold, RL-1359, RW-351, JGM-01-15, CS-52, RK-1418 and Pant Rai-16. These strains of Indian mustard were collected from the National Research Centre on Rapeseed-Mustard, Sewar, Sharatpur (Raj.). The diallel crosses were made during *rabi* 2002-2003. The 36 F_1, 36 F_2 and nine parents were planted in randomized block design with three replications in *rabi* 2003-2004 and 2004-2005 at Agricultural Research Farm, Narain College, Shikohabad affiliated to Dr. Bhim Rao Ambedkar University, Agra. Each plot consisted of singlr row for F_1 and three rows for F_2 of 4m length with inter- and intra row spacings of 45 cm and 15 cm, respectively. A basal dose of NPK @ 40:20:20 kg/ ha was given just before seed sowing. One non experimental rowwas sown on both sides of each replication to avoid border effect.

Standard agronomic and plant protection practices were followed as and when required to raise good and healthy crop under plant protection practices were followed as and when required to raise good and healthy crop under irrigated condition. The observations were noted on 10 (parents and F_1) and 20 (F_2s) randomly selected healthy plants in each plot and also from each rep,lication for days to first flowering (mean in days on row basis), plant height (em), main raceme length (em), number of primary branches/plant, number of secondary branches / plant, number of siliquae on main raceme, siliqua length (cm), 1000-seed weight (g), seed yield/plant (g) and oil content/plant (%). The oil content/ plant in per cent was measured by using official methods of analysis of the nAssociation of Official Analytical Chemists (AOAC, 1985). The mean values of each observation were used to determine genetic components of variation as per Hayman (1954) and combining ability analysis following Method II, Moder I of Griffing (1956).

RESULTS AND DISCUSSION

The mean sum of squares and appropriate degree of freedom are given in Table 1. The 'F' test showed significant differences among F_1 and F_2 populations for all characters. In both F_1 and F_2 diallel analysis, additive component ($\hat{D}$) was found significant for all the characters except number of secondary branches for and seed yield per plant in F_1 only. The estimates of two dominance components ($\hat{H}_1$ and $\hat{H}_2$) were also observed significant for all the characters in F_1 as well as F_2. The third measure of non-additive component, $\hat{h}_2$, which was recorded significant for most of the characters except days to first flower in F_1, but non-significalt in F_2 except for siliquae on main receme, 1000-seed weigt, seed yield per plant and oil content. These results of the present study suggested the importance of both additive and non-additive components in mustard (Table 2). These results are in agreement with the findings of Varma and Kushwaha (1999), Kant and Gulati (2001) and Singh and Sachan (2003).

The relative proportion of $\hat{H}_1$ and $\hat{D}$, which gives the estimate of average degree of dominance, revealed that the magnitude of non-additive component was higher than-that of additive components for all the ten characters studied except days to first flower F_1. It is thus evident from analysis of components of genetic

Table 1. Analysis of variance for economic characters in 9x9 diallel F1 and F2 progenies of Indian mustard

Sources of variance	Popula-tions	d.f.	Days to first flower	Plant height (cm)	Main raceme length (cm)	No. of primary branches	No. of secondary branches raceme	No. of siliquae on main	Siliqua length (cm)	Test weight (g) (g)	Seed yieldl plant	Oil content (%)
Replications	F1	2	0.95	68.20	0.76	0.02	0.08	0.40	0.003	0.001	0.78	1.10
	F2	2	0.36	60.10	3.01	0.14	0.40	0.18	0.002	0.03	0.65	1.96
Treatments	F1	44	57.33**	626.48**	205.92**	5.77**	12.79**	101.60**	0.45**	0.73**	21.37**	42.32**
	F2	44	49.43**	421.52**	125.34**	3.29**	4.62**	51.74**	0.39**	0.64-	16.21**	53.54**
Error	F1	88	2.16	7.88	1.25	0.04	0.02	0.78	0.002	0.005	0.82	1.56
	F2	88	2.22	4.39	3.68	0.05	0.09	0.73	0.002	0.006	0.69	2.01

** Significant at 1% level of probability

Table 2. The estimates of genetic variances, combining ability, mean degree of dominance and nature of gene effects for ten characters in F1 and F2 diallel analysis in Indian mustard

Characters	Populations	Components of genetic variances				Combining ability		Mean degree of dominance	82g 82 s	Gene-effects
		D	HI	H2	h2	GCA	SCA			
Days to first flower	F,	31.79**	29.36**	22.96*	1.08	76.64**	6.73-	0.96	0.10	PA
	F2	31.77-	123.80**	89.65**	1.53	61.89**	7.95-	1.97	0.10	PNA
Plant height (cm)	F,	180.00-	186.20**	170.80**	494.42**	821.42**	71.07**	1.01	0.10	PA
	F2	201.20**	401.50**	323.50**	2.19	671.31	4.80**	1.41	0.10	PNA
Main raceme length (cm)	F,	83.39-	216.30**	176.10**	575.64**	93.64**	63.91-	1.61	0.10	PA
	F2	82.25**	543.50**	390.40**	36.74	103.95	29.62-	2.57	0.10	PNA
No. of primary branches	F,	0.62*	6.66-	6.29**	8.30**	2.26-	1.85**	3.26	0.10	PA
	F2	0.62*	5.17**	4.75-	0.14	0.92**	0.32**	2.88	0.10	PNA
No. of secondary branches	F,	2.22	14.41**	12.83**	7.96**	9.24**	3.59**	2.97	0.01	PA
	F2	2.17-	20.38**	15.79**	0.55	3.50-	1.12-	3.05	0.10	PNA
No. of Siliquae on main raceme	F,	14.05*	107.20**	92.76**	347.14**	31.32**	32.52**	2.76	0.09	PA
	F2	14.07*	233.30**	174.30**	20.63**	38.38**	12.59**	4.07	0.10	PNA
Siliqua length (cm)	F,	0.15**	0.35**	0.30**	0.92**	0.29**	0.11**	1.48	0.10	PA
	F2	0.15-	1.51**	1.19-	0.02	0.34**	0.08-	3.09	0.10	PNA
Test weight (g)	F,	0.32**	0.42**	0.37**	1.22**	0.68**	0.13-	1.14	0.10	PA
	F2	0.32**	1.39**	1.17-	0.22**	0.34**	0.09**	2.07	0.10	PNA
Seed yield I plant (g)	F,	1.67	19.19**	16.61**	50.72**	12.54**	5.85**	3.38	0.09	PA
	F2	1.92**	24.68**	21.05**	10.42**	3.79**	1.61-	3.58	0.10	PNA
Oil content (%)	F,	3.42**	31.23**	30.45**	65.36**	2.35**	1.36**	3.02	0.10	PA
	F2	3.15-	45.22**	33.25**	8.24**	2.05**	1.15**	3.79	0.10	PNA

*, ** Significant at 5% and 1 % level of probability, respectively.
PA = Predominance of additive, PNA = Predominance of non-additive.

variances that there was a general agreement between the dominance relations for days to flower, siliquae on main receme, siliqua length, seed yield per plant and oil content in F_2. However, there was disagreement for plant height, primary branches and test weight in F1 as well as F_2, for main raceme length and secondary branches in F_1 and days to flower and siliqua length in F_2. This may be attributed to significant eaistatic effects recorded for these traits. The presence of epistasis seems to have inflated the estimates of degree of dominance, also postulated by Hayman (1954) and Jinks (1955).

The combining ability analysis also depicted analogous results. Both the GCA and SCA variances (additive and non-additive effects, respectively) were found highly significant for all the characters in both F_1 as well as F_1 as well as F_2 dialled analysis. Further, the GCA mean squares were invariably observed higher than the SCA mean squares for all the characters. Thus, these result expressed that additive gene action seemed to be mainly responsible for the expression of yield and yield contributing traits in both populations, and non-additive action for the siliquae on main raceme in F_1. But a different picture emerged when the estimates of variances due to GCA (δ^2g) and SCA (δ^2S) were observed and δ^2g/δ^2S was compared with GCA/SCA. The magnitude of δ^2S was observed higher than that of δ^2g for all the chqrqcters, clearly indicating the preponderance of non-additive gene action. These results showed that, GCAISCA did not always project the true picture of the gene action for a particular character. Similar findings in Brassica Juncea have been reported by Jindal and Labana (1986).

A comparison of the nature and magnitude of the components of genetic variances of the different characters in F_1 and F_2 diallel analysis revealed that the trend remained more or less parallel. Component analysis for all the characters showed that the average degree of mominance increased marginally in the F_2 when compared with the F_1. The combining ability did not differ significantly in the F_1 and F_2 for most of the characters.

The simultaneous importance of additive and non additive components, influencing the expression of seed yield per plant and its components, suggests that breeding new hybrid strains in mustard by pedigree method, would mean only partial exploitation of additive genetic variance. In such a situation, as revealed in the present study, it is suggested that breeding procedure which may accumulate the fixable gene effects and at the same time maintain considerable amount of heterozygosis for exploiting the dominant gene effects, will prove most effective. Further, the dominance and epistatic components can also be exploited through heterosis breeding as the presence of cytoplasmic male sterility in Indian mustard has been confirmed by Rawat and Anand (1979) and Brar *et al.* (1980).

Genetic informations obtained from diallel analysis based on F_1 data was analogous to the informations obtained following the same analysis using F_2 data. The differences observed over the two generations can be said to be in accordance with the expected genetic constitution of the populations. Thus, from the over all findings it is concluded that equally reliable genetic informations can be investigated from diallerl analysis, utilising F_1 as well as F_2 data.

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BIOASSAY STUDY OF PENDIMETHALIN IN WHEAT-*POLYGONUM* ASSOCIATION UNDER *TERAI* AGRO-ECOLOGICAL REGION OF WEST BENGAL

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ABSTRACT

Field experiments were carried out during the *rabi* season of 2004-05 and 2005-06 on sandy loam soil at Uttar Banga Krishi Vishwavidyalaya with the objectives to determine dose and degree of selectivity of pendimethalin through the measurement of selectivity index in wheat in order to achieve control on weeds especially *Polygonum* sp the dominant weed flora in the terai agro ecological region of West Bengal. Preemergence herbicide pendimethalin with the doses of 0.00, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 1.00, 1.20, and 1.40 kg /ha were applied in wheat and the doses of 0.00, 0.1 0, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80 and 1.20 kg /ha were applied in *Polygonum*. Herbicide was applied in micro-plot having plot size of 2sq m area in both wheat and *Polygonum*. Plant samples were taken at 20 and 40 days after sowing and biological response of plant to herbicide in terms of per cent growth inhibition was determined by comparing the fresh weight of the plants grown in herbicide treated plots with healthy plants from untreated plot. Phytotoxicity of pendimethalin on wheat appeared within 8 to 10 days after sowing (DAS) with the appearance of yellowing necrotic symptom and that was followed by complete death of seedling within 12 to 15 DAS. Pendimethalin with the dose ranging from 0.49 to 0.51 kg /ha became selective in action in wheat to control *Polygonum* with the selectivity index values of 1.06 and 1.08 at 20 DAS and 40 DAS in the year 2004-05 and 1.03 and 1.1 at 20 DAS and 40 DAS in the year 2004 and 2005, respectively.

Key words : Bioassay, pendimethalin, *polygonum*.

Chemical methods of weed control through herbicide play a vital role as a cost effective tool in integrated weed management programme and are being widely used in the present day agriculture. The terai agro-ecological zone has a characteristic of typical sub- tropical humid climate with high annual rainfall (more than 3000 mm) and high relative humidity resulting in aggressive growth of the weeds, which often become obnoxious. Nevertheless, the soils in this region developed under the influence of high rainfall and intense leaching condition are coarse in texture and shows multiple nutrient deficiencies. Profuse growth of several weeds with high invasive capacity coupled with poor fertility status often became limiting factor in crop cultivation. Non-selective action of pendimethalin and its phytotoxicity on wheat observed in field condition under terai gro-ecological region led to the need to find out the dose of pendimethalin that become safe for use as preemergence treatment in wheat for controlling *Polygonum*, the most obnoxious weeds associated with winter crops. The bioassay experiment has been planned with the objective to determine dose and degree of selectivity of pendimetalin through the measurement of selectivity index. This technique usually lead to identify the herbicides that are safe for a crop in terms of phytotoxicity and growth reduction by relating the different herbicidal doses with the percent reduction in fresh weight of individual plants (Tag-El-Din *et al.*, 1981).

MATERIALS AND METHODS

A field experiment was carried out during the *rabi* season of 2004-05 and 2005-06 at the Research Farm of Uttar Banga Krishi Viswavidyalaya located at Pundibari, Cooch Behar, W.B. The soil of the experimental site was sandy loam in character with pH 5.34-5.8, organic carbon 0.45%, available N 112.80 kg/ha, available

Table 1. Does of herbicide (kg /ha), corresponding logarithmic dose of herbicide, dry weight of wheat (g) influenced by different doses of herbicide, percent growth inhibition of wheat and its crresponding probit value at 20 DAS

Dose of pendimethalin (kg /ha)	Log dose (X)	Dry weight (g)		Growth inhibition (%)		Probit value (Y)	
-	-	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
0.00	0.000	2.2000	2.1700	-	-	-	-
0.20	-0.669	2.1758	2.1417	1.10	1.30	2.7006	2.7897
0.30	-0.523	2.1340	2.1049	3.00	3.00	3.1192	3.1192
0.40	-0.398	2.0988	2.0701	4.60	4.60	3.3151	3.3151
0.50	-0.301	2.0944	2.0376	4.80	6.10	3.3354	3.4536
0.60	-0.222	2.0020	1.9725	9.00	9.10	3.6592	3.6654
0.70	-0.155	1.9910	1.9530	9.50	10.00	3.6894	3.7184
0.80	-0.097	1.8964	1.8792	13.8	13.40	3.9107	3.8923
1.00	0.000	1.0780	1.085	51.0	50.00	5.0251	5.0000
1.20	0.079	0.9196	0.8180	58.20	62.30	5.2070	5.3134
1.40	0.146	0.4092	0.4053	81.40	81.32	5.8927	5.8901

Table 2. Does of herbicide (kg /ha) corresponding logarithmic dose of herbicide, dry weight of wheat (g) influenced by different doses of herbicide, percent growth inhibition of wheat and its crresponding probit value at 40 DAS

Dose of pendimethalin (kg/ha)	Log dose (X)	Dry weight (g)		Growth inhibition (%)		Probit value (Y)	
-	-	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
0.00	0.000	12.3000	12.1000	-	-	-	-
0.20	-0.669	12.1647	11.9669	1.10	1.10	2.7006	2.7006
0.30	-0.523	12.0048	11.8459	2.40	2.10	3.0226	2.9665
0.40	-0.398	11.9802	11.5676	2.60	4.40	3.0500	3.2940
0.50	-0.301	11.9310	11.5434	3.00	4.60	3.1192	3.3151
0.60	-0.222	11.7342	11.3619	4.60	6.1	3.3151	3.4536
0.70	-0.155	11.1807	10.9989	9.10	9.10	3.6654	3.6654
0.80	-0.097	10.6518	10.8900	13.40	10.00	3.8923	3.7184
1.00	0.000	6.2853	7.0059	48.90	42.10	4.9724	4.8007
1.20	0.079	5.3874	5.2030	56.20	57.00	5.1558	5.1764
1.40	0.146	2.8659	3.4606	76.70	71.40	5.7290	5.5651

phosphorus 16.35 kg/ha and available potash 76.9 kg/ha. The locally cultivated wheat variety sonalika was used in the experiment. In wheat pendimethalin with the doses of 0.00. 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 1.00, 120, and 1.40 kg /ha and in case weeds (*Polygonum*) pendimethalin with the doses of 0.00, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 1.10 and 1.20 kg / ha were used in the field experiment having plot size of 2sq m area. Both wheat and weed plant samples were taken at 20 and 40 days after sowing (DAS) from 20 cm x 20 cm sample area. Visual observations were made every day to understand the changes in growth behavior of

Table 3. Does of herbicide (kg a.i/ha), corresponding logarithmic dose of herbicide, dry weight of Polygonum (g) influenced by different doses of herbicide, percent growth inhibition of *Polygonum* and its crresponding probit value at 20 DAS

Dose of herbidde (kg a.i./ha)	Log dose (X)	Dry weight (g)		Growth inhibition (%)		Probit value (Y)	
0.00	0.00	1.7400	1.6800	-	-	-	0.0000
0.1	-1	1.4007	1.3120	19.50	21.90	4.1404	4.2244
0.2	-0.699	1.1240	1.0852	35.40	35.40	4.6255	4.6255
0.3	-0.523	0.8891	0.8500	48.90	49.40	4.9724	4.9850
0.4	-0.398	0.5742	0.4569	67.00	72.80	5.4399	5.6068
0.5	-0.301	0.3236	0.4418	81.40	73.70	5.8927	5.6250
0.6	-0.222	0.2836	0.2184	83.70	87.00	5.9822	6.1264
0.7	-0.155	0.1426	0.1814	91.80	89.20	6.3917	6.2372
0.8	-0.097	0.1200	0.1344	93.10	92.00	6.4833	6.4051
1.0	-0.00	0.0904	0.0772	94.80	95.40	6.6258	6.6646
12	0.079	0.0189	0.0191	98.91	98.86	7.2938	7.2766

Table 4. Does of herbicide (kg a.i/ha), corresponding logarithmic dose of herbicide, dry weight of *Polygonum* (g) influenced by different doses of herbicide, percent growth inhibition of *Polygonum* and its crresponding probit value at 40 DAS

Dose of herbidde (kg a.i./ha)	Log dose (X)	Dry weight (g)		Growth inhibition (%)		Probit value (Y)	
-	-	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
0.00	0.00	4.4200	4.1200	-	-		0.0000
0.1	-1	3.5581	3.3166	19.50	19.50	4.1404	4.1404
0.2	-0.699	2.8951	2.69.86	34.50	34.50	4.6011	4.6011
0.3	-0.523	2.2586	2.1053	48.90	48.90	4.9724	4.9724
0.4	-0.398	1.5028	1.2154	66.00	70.50	5.4125	5.5388
0.5	-0.301	0.8707	1.0959	80.30	73.40	5.8542	5.6250
0.6	-0.222	0.7425	0.5397	83.20	86.90	5.9621	6.1217
0.7	-0.155	0.4773	0.4449	89.20	89.20	6.2372	6.2372
0.8	-0.097	0.3624	0.3378	91.80	91.80	6.3917	6.3917
1.0	-0.00	0.2607	0.2018	94.10	95.10	6.5632	6.6546
1.2	0.079	0.0503	0.0770	98.86	98.13	7.2766	7.0814

the plants and appearance of phytotoxic symptom owing to herbicidal toxicity on plant at different doses. Biological response of plants to herbicides was determined by measuring the fresh weight of the plants grown in herbicide treated soil with different doses and per cent growth inhibition of plant was calculated by comparing the fresh weight of herbicide treated plant with healthy plant from untreated plot. The percent growth inhibition values obtained at different herbicidal doses both in case of wheat and weed were transformed to probit values and plotted against log values of the doses (Tables 1-4). A straight line was obtained through computation of

Table 5. Regression equation between probit value and logarithmic dose of herbicide, r2 value, GR10 value (kg a.i/ha) of wheat, Gr 50 value (kg a.i/ha) vheat and polygornum, Gr 80 value (kg a.i/ha) of Polygonum and selectivity index.

	Wheat at 20 DAS		Weed (Polygonum) at 20 DAS		Wheat at 40 DAS		Weed (Polygonum) at 40 DAS	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
Regression equation	Y=3.6561X + 4.7678	Y=3.6136X + 4.789	Y=2.8964X + 6.7452	Y=2.7946X + 6.7044	Y=3.6744X + 4.6886	Y=3.4241X + 4.5983	Y=2.8273X + 6.6787	Y=2.7795X + 6.6581
r^2 value	0.8592	0.8550	0.%28	0.9551	0.8407	0.8578	0.9606	0.9720
GR^{10} values (kg/ha)	0.516	0.505	-	-	0.544	0.553	-	-
GR 50 values (kg/ha)	1.157	1.144	0.25	0.246	1.215	1309	0.254	0.253
GRs. values (kg/ha)	-	-	0.488	0.491	-	-	0.506	0.503
Selectivity Index	S.I.= 0.516/0.488 = 1.057 (for 2004-05) S.I.= 0.505/0.491 = 1.028 (for 2005-06)				S.I.= 0.544/0.506 ==1.075 (for 2004-05) S.I.= 0.553/0.503 =1.099 (for 2005-06)			

regression equation (Y=Mx + C where, Y= probit value, M= regression coefficient, x= log dose and C= constant) reflecting response of plants at different dose of herbicides. Selectivity index (S.I.) value was calculated by formula S.I. = maximum doses tolerated by the crop/ minimum does required to control the weeds. Maximum dose of herbicide tolerated by wheat crop was equal to the dose that caused 10% growth reduction of wheat at initial stage and minimum does required to control the weeds (*Polygonum*) was equal to the dose that resulted in 80% growth reduction of weed or 80% weed control efficiency. S.I. value>1 is always desirable to get selective control over weeds without any lethal effect on crop plant. The proportional increase of plant response in terms of growth reduction to herbicide dose led to identify the level at which the plant produce 50% response which is known as GR_{50} (dose that cause 50% response). GR_{50} values show relative sensitivity of crops to herbicides (Nel, *et al.*, 1995).

RESULTS AND DISCUSSION

Weed flora

Weed flora of the experiment comprised different species of *Ploygonum* like *P. persicaria* L., *P. Pensylvanicum* L., *P. orientale* L. and *P. odoratum* L.

Phytotoxicity and selectivity index of herbicide

The phytotoxic effect to the wheat plant was manifested with characteristic yellowing and necrotic symptom that appeared within 8-10 DAS in the leaves of newly emerged seedling. Appearance of yellowing and necrotic symptom was followed by death of seedling within 12-15 DAS. Selectivity index value of pendimethalin for wheat *-polygonum* association were 1.06 and 1.03 at 20 DAS during 2004 and 2005, respectively in which GR_{10} values of wheat were 0.516 and 0.505 kg/ha and GR_{80} values of weed (*Polygonum*) were 0.488 and 0.491 kg/ha during 2004 and 2005, respectively. At 40 DAS selectivity index values were 1.08 and 1.1 in which GR_{10} values of wheat were 0.544 and 0.553 kg a.i/ha and GR80 values of weed (*Ploygonum*) were 0.506 and 0.503 kg/ha during 2004 and 2005, respectively (Table 5).

Dose of pendimenthalin

S.I. value>1 ensured selectivity of pendimethalin in wheat-*Polygonum* association to achieve 80% weed control efficiency with the dose ranging from 0.49 to 0.51 kg/ha. Maintaining S.I. value>1 up to 40 DAS indicated persistence of pendimethalin in soil at least for the period of 40 DAS for controlling weed (*Polygonum*) in wheat.

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RESIDUAL EFFECT OF VERMICOMPOST, CHEMICAL FERTILIZER AND BIOFERTILIZER IN WHEAT (*TRITICUM AESTIVUM*) ON SUCCEEDING FODDER COWPEA (*VIGNA UNGUICULATA*)

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ABSTRACT

A field experiment was conducted during 2003-04 and 2004-05 to evaluate residual effect of integrated nutrient management in wheat (*Triticum aestivum*) on succeeding fodder cowpea (*Vigna unguiculata*) under *terai* region of West Bengal. The treatments comprised two levels of vermicompost (no vermicompost and vermicompost @ 5 tonnes/ha), three fertility levels (100, 75 and 50 % recommended dose of NP) and four biofertilizer treatments (No inoculation, *Azotobacter*, PSB and co-inoculation of *Azotobacter* and PSB). Vermicompost application @ 5 tonnes/ha, fertility levels and biofertilizers significantly enhanced yield of wheat and available nutrient status in soil after its harvest. Residual effect of vermicompost and fertility levels significantly influenced fodder yield and nutrients uptake of fodder cowpea and available nutrient status after its harvest. Biofertilizers also showed significant residual effect on yield and nutrients uptake of cowpea (fodder) and available P status in soil after fodder cowpea harvest.

Key words : Residual effect, vermicompost, fertility levels, biofertilizer, wheat, fodder cowpea.

Wheat (*Triticum aestivum* L.) is one of the important crops in winter season in *terai* region of West Bengal. Application of fertilizers enhances crop growth and yield but exclusive use of chemical fertilizers may lead to stagnation or decline in productivity due to emerging deficiency of other nutrients and degradation of soil health (Patidar and Mali, 2001). Moreover, the increasing cost of fertilizers prevents their use of resource poor farmers. So, there is need to adopt concept of integrated nutrient management involving bio, organic and inorganic sources of nutrients. Integrated use of fertilizers, manures and biofertilizers may help in minimizing the cost of chemical fertilizers, improve soil productivity and sustains productivity of crop. It is also seen that fertilizer supply to one crop has residual effect on succeeding crop (Mehta *et al.*, 2004). About less than 30% of nitrogen and small fraction of phosphorus and potash in organic manure may become available to immediate crop and rest to subsequent crops (Patidar and Mali, 2002). So, integrated nutrient management not only increases the productivity of one crop but also have some residual effect on succeeding crop. In terai region, land after wheat remains mostly fallow which can be effectively utilized by growing fodder legume on residual fertility. Since the information on residual effect of integrated nutrient management on fodder cowpea after wheat is lacking for this zone, the present study was conducted to assess the effectiveness of residual effect of vermicompost, chemical fertilizer and biofertilizers applied to wheat on yield, uptake and soil fertility of cowpea (fodder).

MATERIALS AND METHODS

A field experiment was conducted during 2003-04 and 2004-05 at Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Cooch Behar. The soil was sandy loam in texture with organic carbon 1.03%, available N, P_2O_5 and K_2O @185, 22.6 and 128.3 kg/ha, respectively and with pH 5.6. The treatments consisted of 2 levels of vermicompost (No vermicompost and vermicompost @ 5 tonnes/ha), three fertility levels (100, 75 and 50% recommended dose of NP) and four levels of biofertilizer (no inoculation, *Azotobacter*, PSB and *Azotobacter* + PSB co-inoculation). These treatments were evaluated in split-split plot design with 3 replications. Recommended dose of fertilizer for wheat was 80 kg N and 40 kg P_2O_5 /ha. A uniform dose of 40 kg K_2O/ha was applied to all treatments. The wheat variety NW 1014 was sown 18 cm apart using a seed rate of 125 kg/ha in 15th December and 11th December of 2003 and 2004, respectively. Fodder cowpea (EC 4216) was raised on residual fertility of wheat. The crop was sown at a spacing of 30 x 8 cm using a seed rate of 35 kg/ha. The crop was sown by 1st fortnight of April and harvested after 50 days crop age. Observations on yield parameters of each crop were recorded. Available N and P_2O_5 content in soil at 20 cm depth from each plot after wheat and fodder cowpea harvest were estimated separately. Plant samples of fodder cowpea were collected at harvest and analysed for total N (modified micro kjeldahl's method), P (vanado-molybdate phosphoric acid yellow colour method by spectrophotometer) and K (flame photometer).

RESULTS AND DISCUSSION

Vermicompost application significantly increased grain and straw yield by 24.48 and 11.97%, respectively (Table 1). The favourable effcct of vermicompost on chemical, physical and biological properties of soil might have resulted in higher yield. Application of 100% recommended dose of NP resulted in significantly higher grain and straw yields over lower levels of fertility. The significant increase in yield of wheat with increasing fertility levels could be attributed to conducive effect of fertilizer (N and P) on plant growth. The results corroborated the findings of Nehra *et al.* (2001) and Kumar and Singh (2003). Grain and straw yield of wheat varied significantly due to biofertilizer inoculation. Among biofertilizers, dual inoculated crop gave significantly higher grain yield compared with no inoculation and PSB inoculation alone. However, inoculation of Azotobacter alone was at par with this treatment. Dual inoculation recorded 7.66, 4.55 and 2.35% higher grain yield over no inoculation, PSB alone and Azotobacter alone respectively. The favourable nutritional environment under the influence of biofertilizer might have resulted in improved crop growth and finally the yield. The results confirmed the findings of Panwar and Singh (2000) and Patidar and Mali (2001).

Vermicompost application had significant effect on available Nand P_2O_5 status of soil. Available Nand P_2O_5 status in soil after wheat harvest with vermicompost was higher by 8.57 and 15.20% respectively. The increase in N and P_2O_5 status in soil was due to release of Nand P on decomposition of vermicompost. These results were in accordance with the findings of Nehra and Hooda (2002).

Progressive increase in fertility level resulted into significant increase in available Nand P_2O_5 status of soil after wheat harvest (Table 1). Maximum available N and P_2O_5 were recorded with 100% recommended dose of NP, being significantly higher over lower levels. Application of 100% recommended dose of NP improved available N status of soil by 3.15 and 5.80% and available P_2O_5 status of soil by 5.78 and 11.95% over 75% and 50% recommended dose of NP respectively. The significant improvement in Nand P_2O_5 status of soil after wheat harvest might be due to nitrogen and phosphorus build-up in soil as a result of addition of Nand P through fertilizer. These results confirmed the findings of Singh and Rawat (2002).

Bacterial inoculations significantly influenced available Nand P_2O_5 status in soil after wheat harvest. *Azotobacter* alone and in combination with PSB significantly enhanced available N status of soil by 2.24 and 2.49% respectively, over no inoculation. Higher soil available nitrogen in Azotobacter inoculated plots was due to N-fixing capacity of Azotobacter. Whereas, PSB alone and in combination with Azotobacter improved P_2O_5 status of soil significantly by 6.70 and 6.33% respectively, over no inoculation. Increased phosphorus availability in PSB treated plots could be attributed to more solubilization of native as well as applied phosphorus by the phosphorus solubilizing bacteria.

Vermicompost applied to wheat significantly enhanced green and dry fodder yield of fodder cowpea to the extent of 16.86

and 23.06% respectively over no vermicompost. Higher fodder yield with vermicompost may be due to the fact that vermicompost not only supplied nutrients to the current crop but also leaves substantial amount to the next crop. The results were in accordance with the findings of Abraham and Lal (2002). Residual effect of fertility level showed significant variation in green and dry fodder yield of cowpea (fodder). Application of 100% recommended dose of NP to wheat significantly increased green and dry fodder yield of fodder cowpea, over lower fertility levels. Green fodder yield with residual effect of 100% recommended dose of NP was significantly increased by 3.13 and 6.70% over 75% and 50% recommended dose of NP, respectively. This might be due to greater residual effect with 100% recommended dose ofNP over lower fertility levels. Green and dry fodder yield of fodder cowpea varied significantly with residual effect 0 bacterial inoculations. Highest green (204.32 q/ha) and dry (37.06 q/ha) fodder yields were obtained with co-inoculation of Azotobacter and PSB which was elosely followed by inoculation with Azotobacter alone. Higher fodder yield obtained in biofertilizer inoculated plots could be attributed to the fact that all the fixed-N or solubilized-P are not utilized by current crop and substantial amount left for subsequent crop. Residual effect of biofertilizer on succeeding crop was also reported by Gaur (1988).

The uptake of N and P by fodder cowpea increased significantly due to residual effect of vermicompost by 25.81 and 36.16% respectively over no vermicompost. This could be ascribed to their increased availability in soil and increased biomass production as a result of residual effect of vermicompost application. Fertility levels had significant residual effect on Nand P accumulation by fodder cowpea. Residual effect of 100% recommended dose ofNP increased N accumulation by 7.12 and 18.75% and P accumulation by 15.23 and 41.79% over 75% and 50% recommended dose of NP respectively. The

Table 1. Effect of vermicompost, fertility levels and biofertilizers on wheat yield and soil fertility after whet harvest (pooled data of 2 years)

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Available nutrient statuis in soil after wheat harvest (kg/ha)	
			N	P_2O_5
Vermicompost (t/ha)				
0	21.77	33.91	173.62	23.48
5	27.10	37.97	188.50	27.05
CD (P = 0.05)	0.50	0.53	0.90	0.56
Fertility levels				
100% NP	26.93	38.76	186.36	26.70
75%NP	24.99	36.23	180.67	25.24
50% NP	21.38	32.85	176.15	23.85
CD (P = 0.05)	0.49	0.39	1.58	0.54
Biofertilizers				
No inoculation	23.50	34.81	179.01	24.47
Azotobacter	24.72	36.34	183.02	24.46
PSB	24.20	35.74	178.75	26.11
Azotobacter + PSB inoculation	25.30	36.89	183.46	26.02
CD (P = 0.05)	1.00	1.29	4.03	1.08

Table 2. Residual effect of vermicompost, fertility levels and biofertilizers on yield and nutrient uptake of fodder cowpea and coil fertility atter fodder cowpea harvest (pooled data of 2 years)

Treatment	Fodder yield (q/ha)		Nutrients uptake (kg/ha)		Available nutrient statuis in soil after cowpea harvest (kg/ha)	
	Green	Dry	N	P	N	P_2O_5
Vermicompost (t/ha)						
0	183.97	31.88	85.29	8.85	139.40	18.84
5	214.99	39.23	107.30	12.05	151.16	20.51
CD (P = 0.05)	1:75	0.60	1.71	0.14	1.98	0.43
Fertility levels						
100% NP	205.87	37.80	104.08	12.18	148.72	20.58
75%NP	199.63	35.87	97.16	10.57	145.39	19.76
50% NP	192.93	32.99	87.65	8.59	141.73	18.6R
CD (P = 0.05)	2.13	0.85	2.51	0.30	1.13	0.63
Biofertilizers						
No inoculation	195.09	34.47	92.55	9.56	143.97	19.17
Azotobacter	200.20	35.64	96.68	10.60	146.54	19.03
PSB	198.30	35.05	94.59	10.01	143.76	20.16
Azotobacter + PSB inoculation	204.32	37.06	101.37	11.61	146.84	20.34
CD (P = 0.05)	6.10	1.52	4.16	0.50	NS	0.99

increase in available N and P_2O_5 in soil by fertilizer application resulted marked increase in the concentration of these nutrients and their uptake hy cowpea (fodder). N and P uptake of fodder cowpea varied significantly with residual effect of biofertilizer treatments. Dual inoculation of biofertilizer enhanced N uptake by 4.85, 7.17 and 9.53% and P uptake by 9.53, 15.98 and 21.44% over *Azotobacter* alone, PSB alone and no inoculation, respectively. Higher N and P uptake by fodder cowpea in biofertilizer inoculated plots could be attributed to the fact that N-fixed or P-solubilized in soil by bacterial inoculations in wheat field also had carry out effects on fodder cowpea.

N and P_2O_5 status of soil after fodder cowpea harvest were significantly influenced by vennicompost and fertility levels. Mean available N and P_2O_5 status of soil after fodder cowpea harvest were 151.16 and 20.51 kg/ha, respectively with vermicompost and 139.40 and 18.84 kg/ha respectively without vermicompost. The increased nutrient status (N and P_2O_5) may be due to effect of organic matter with vermicompost application. Application of 100% recommended dose of NP resulted in significantly higher available N (148.72 kg/ha) and P_2O_5 (20.58 kg/ha) after fodder cowpea harvest over lower levels of fertility. This was due to residual effect of applied fertilizer. Biofertilizers did not show perceptible variation in available N status of soil after harvest of fodder cowpea. Available P_2O_5 status of soil after fodder cowpea harvest varied significantly with residual effect of biofertilizer. Due to residual effect of biofertilizer, highest available P_2O_5 status in soil after harvest of fodder cowpea (20.34 kg/ha) was recorded with dual inoculation which was closely followed by PSB alone (20.16 kg/ha). This could be attributed to the fact that P-solubilized by PSB in wheat was not utilized by current crop and substantial amount was left for next crop.

It was concluded that application of vennicompost fertilizer and biofertilizer in wheat had significant residual effect on subsequent fodder cowpea. Productivity of fodder cowpea was found to be maximum with residual effect of vennicompost @ 5 tonnes/ha and 100% recommended dose of NP along with co-inoculation of biofertilizers.

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ENHANCEMENT OF YIELD AND QUALITY ATTRIBUTES OF POMEGRANATE (*PUNICA GRANATUM* L.) CV. GANESH THROUGH NITROGEN AND NEEMCAKE APPLICATION

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ABSTRACT

A field experiment was carried out to study the effects of nitrogen and neemcake on yield and quality of pomegranate cv Ganesh. Four levels of nitrogen (100, 200, 300 and 400 g/plant/year) and 1 kg neemcake/plant/year were applied singly and in combination. A common dose of 100 g of P_2O_5 and 100 g K_2O were also applied to all the plants including control. The data revealed that the highest fruit yield (6.94 kg/plant) with heaviest fruit (239.83 g), highest T.S.S. (12.290B), total sugar (10.74%), reducing sugar (9.78%), Vitamin-C, (21.93 mg/100 mljuice) and a comparatively lower acidity (0.39%) were recorded with the application of 300 g nitrogen + 1 kg neemcake/plant/year (T_8). The leaves under this treatment (T_8) contain 1.62% nitrogen, 0.04% phosphorus and 1.02% potassium.

Key words : Nitorgen, neemcake, pomegranate, yield, quality.

Pomegranate is one of the favourite table fruit of tropical and sub-tropical regions. In India, it is considered as a crop of the arid and semi-arid regions because it withstands different soil and climatic stresses, but thrives best in place with a hot dry summer having irrigation facility to some extent. Mineral nutrition plays an important role in influencing the yield and quality of fruits (Pathak and Pundir, 1981; Kumar and Tung, 1987). There are various orchard management practices to increase the productivity and quality of the crop. But among them, application of manures and fertilizers at proper dose and time is one of the most important one. The present investigation was undertaken to compare the differential effects of nitrogen and neemcake on yield and fruit quality of pomegranate cv. Ganesh.

MATERIALS AND METHODS

The experiment was undertaken at the Horticultural Research Station, Mondouri, of Bidhan Chandra Krishi Viswavidyalaya, during the period from October, 2002 to June, 2004 on 4 years old plants of pomegranate cv. Ganesh. The plants under treatment were fertilized with four levels of nitrogen (100, 200, 300 and 400 g/plant/year) and 1 kg neemcake constituting the following treatment combinations i.e. T_1 = 100 g nitrogen/plant/year; T_2 = 200 g nitrogen/plant/year; T_3 = 300 g nitrogen/plant/year; T_4 = 400 g nitrogen/plant/year; T_5 = 1 kg neemcake/plant/year; $T_6 = T_5 + T_1$; $T_7 = T_5 + T_2$; $T_8 = T_5 + T_3$; $T_9 = T_5 + T_4$ and T_{10} = Control. A common dose of 100 g P_2O_5 and 100 g K_2O/plant/year was given to all plants including control. The mature fruits were harvested and brought to the laboratory for physical and chemical analysis. The physical parameters like fruit weight, length, diameter of fruit and yield were measured. The chemical parameters likeT.S.S., total sugar, titratable acidity (A.O.A.C., 1984) and ascorbic acid (Ranganna, 1977) were determined by following the standard procedure. The leaf nutrients were estimated from the leaves collected from the fruiting shoot during April followng the method as described by nitrogen (Black, 1965), phosphorus (Jackson, 1960), potassium (Piper, 1956). The experiment was conducted in randomized block design with three replications. The data were analysed statistically and were evaluated.

RESULTS AND DISCUSSION

Investigation revealed that higher dose of nitrogen increases nitrogen and potassium content of the leaves while foliar phosphorus content decreases slightly. The highest foliar nitrogen and potassium content was recorded in the treatment 300 g nitrogen + 1 kg neemcake/plant/year (T_8), while lowest amount of phosphorus content was also recorded under the same treatment, which is statistically at par with T9 (Table 1). It is observed that foliar N, K levels are more when neemcake was applied with chemical nitrogen rather than only chemical nitrogen. Highest fruit yield was obtained with the leaf N, P and K concentration of 1.62, 0.04 and 1.02 percent of leaf dry weight during August. Sendhe (1977) reported the optimum leaf nutrient status for satisfactory performance of pomegranate cv. Ganesh as 2.5% N, 0.19% P and 1.47% K.

Fruit production was significantly improved, when chemical nitrogen and neemcake were judiciously applied to the plants. The significantly highest fruit yield was obtained from the treatment with 300 g nitrogen + 1 kg neemcake/plant/year (T_8), which was almost 68.58% more than that of control (no nitrogen) (Table 2). It was observed that 400 g of chemical nitrogen singly or in combination with neemcake were ineffective for further improvement in fruit production which might be due to the juvenality of the plant and also due to promotion of more vegetative growth. Beneficial effect of nitrogen in improving yield in pomegranate was also noted by Singh *et al.* (1988) and again by Prasanna Kumar and Dhandar (1987).

Similarly to that of fruit yield, highest fruit weight, fruit length and lowest seed percentage was recorded from the fruits of the treatment 300 g nitrogen + 1 kg neemcake/plant/year (T_8) (Table 2). The highest T.S.S., total sugar, reducing sugar, non-reducing sugar, vitamin-C were also associated with the same treatment (T_8). A relatively low percentage of acidity (0.39%) was noticed from fruits of that treatment (T g) which was comparatively lower than the fruits of control (Table 3) and it was in conformity with the observation taken by Bankar *et al.* (1990). Singh *et al.* (1988), from another experiment, concluded that the higher doses of nitrogen increases the qualitative characters of the fruits of pomegranate.

In the present experiment, it was apparent that combined application of chemical nitrogen and neemcake along with a common dose of phosphorus and potassium brought about marked improvement in physico-chemical composition of pomegranate fruits. The marked effect of nitrogen on various characters of fruits of pomegranate was due to the fact that it increased the efficiency of metabolic process of the trees and thus encouraged the growth of pomegranate plant in general and consequently the various parts of the plant including fruit. Juice percentage of the fruit was increased due to nitrogen application because they caused better

Table 1. Effect of chemical nitrogen and neemcake on foliar NPK content in pomegranate cv. Ganesh

Treatment	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_1	1.18	0.06	0.79
T_2	1.31	0.06	0.79
T_3	1.37	0.06	0.82
T_4	1.49	0.05	0.96
T_5	1.25	0.06	0.78
T_6	1.41	0.06	0.7
T_7	1.5	0.05	0.96
T_8	1.62	0.04	1.02
T9	1.58	0.04	0.99
T_{10}	0.95	0.06	0.80
S.Em±	0.028	0.004	0.125
C.D. at 5%	0.083	0.012	N.S.

Table 2. Effect of chemical nitorgen and neemcake on yield, fruit weight, size of pomegranate cv. Ganesh

Treatment	Fruit weight (g)	Fruit length (em)	Fruit diameter (em)	Fruit retention (%)	Number of mature	Fruit yield (kg/plant) fruit/plant
T_1	157.9	6.32	6.53	47.36	12.67	2.45
T_2	169.22	6.46	6.49	47.97	17.49	2.71
T_3	184.06	6.85	6.66	48.94	14.61	3.06
T_4	188.61	6.95	6.59	49.4	15.48	5.27
T_5	181.08	6.92	6.98	49.82	20.48	4.00
T_6	201.93	7.18	7.01	48.98	15.52	4.05
T_7	205.80	7.38	6.92	49.55	23.71	4.78
T_8	239.83	7.75	7.23	53.00	29.29	6.94
T_9	215.71	7.3	7.06	51.36	25.23	5.85
T_{10}	146.77	5.70	6.14	43.66	10.26	2.18
S.Em±	2.725	0.164	0.297	0.242	4.530	0.166
C.D. at 5%	8.097	0.489	N.S.	0.719	N.S.	0.493

Table 3. Effect of chemical nitorgen and neemcake on chemical composition of fruits in pomegranate cv. Ganesh

Treatment	Juice (%)	T.S.S. (°Brix)	Acidity (%)	Total Sugar (%)	Reducing Sugar (%)	Vitamin-C (mg/100ml of juice)
T_1	62.1	10.46	0.52	8.88	7.96	20.68
T_2	65.12	10.55	0.53	9.13	8.29	20.97
T_3	64.91	10.69	0.51	9.37	8.68	20.77
T_4	72.16	10.77	0.44	9.69	9.08	20.99
T_5	62.65	10.25	0.51	9.13	8.51	20.68
T_6	69.17	10.9	0.46	9.66	8.67	20.65
T_7	71.75	10.59	0.47	10.32	9.41	21.07
T_8	75.63	12.29	0.39	10.74	9.78	21.93
T_9	73.49	11.59	0.41	10.58	9.36	21.46
T_{10}	60.43	10.44	0.56	8.46	7.64	20.63
S.Em ±	1.369	0.323	0.021	0.026	0.016	0.317
C.D. at 5%	4.069	0.958	0.061	0.078	0.047	N.S.

hydration in the tree and so the fruits were more succulent or juicy. Nitrogen also stimulates the functioning of a number of enzymes in the physiological process which probably caused an increase in the T.S.S. content of the fruit.

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STUDIES ON *RHIZOBIUM* INOCULATION AND NITROGEN AND POTASSIUM LEVELS ON THE PERFORMANCE OF SOYBEAN (*GLYCINE MAX* L.)

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ABSTRACT

Performance of soybean to seed inoculation with *Rhizobium* and levels of nitrogen and potassium was studied in a field experiment on a medium fertile sandy loam soils in the northern plain zone at Lakhaoti, Bulandshahr during *kharif* 2004 and 2005 . The results indicated that seed inoculation with *Rhizobium* recorded higher growth and yield attributes and yield of soybean. Among the levels of nitrogen and potassium, application of 40 kg N and 40 kg K_2O /ha recorded higher growth and yield attributes and grain yield of soybean. There were positive interaction of potassium with *Rhizobium* inoculation and N levels on the dry matter accumulation in soybean at different stages of crop growth.

Key words : *Rhizobium*, inoculation, nitrogen, potassium.

Soybean (*Glycine max* L.) is emerging as a leading oilseed crop in India. It is the most important oilseed crop in India (GOI, 2009). Due to its higher yield potential and as a substitute for low yielding crops in *kharif*, it is getting the attention of the farmers in northern plain zone. Because of its recent introduction in this zone, its response to various inputs needs to be studied for tailoring optimum production technology for this crop in different locations. Since the crop requires relatively higher dose of nitrogen, the effectiveness of *Rhizobium* inoculation and nitrogen levels hold key for realizing higher productivity. Besides nitrogen, soybean also needs a large quantity of potassium and responds very well to added potassium. Keeping these things in view a field experiment was carried out to study the effect of *Rhizobium* inoculation and nitrogen and potassium levels on the performance of soybean.

MATERIALS AND METHODS

A field experiment on soybean was carried out during *kharif* 2004 and 2005 at the Research Farm of Amar Singh (P.G.) College, Lakhaoti, Bullandshahar. The farm is situated at 28°10' N latitude and 77°10' E longitude at an altitude of 228.6 m above mean sea level in the heartland of the Gangetic Plains of the northern plain zone. The soil of the experimental site was sandy loam in texture, low in organic carbon (0.39%)and available phosphorus (9.52 kg P_2O_5/ha) and medium in available potassium (158 kg K_2O/ha) with slightly alkaline in reaction (pH 7.60). The treatments consisted of 2 levels of *Rhizobium* viz. control and *Rhizobium* inoculation; 3 levels of nitrogen viz. 0, 20 and 40 kg/ha, and 3 levels of potassium viz. 0, 20 and 40 kg K_2O/ha. The experiment was laid out in randomized block design and replicated thrice. The graded levels of nitrogen in the form of urea (N 46%) and potassium in the form of murriate of potash (60% K_2O) were applied and mixed in the soil before sowing along with an uniform dose of 60 kg P_2O_5/ha as single super phosphate (16% P_2O_5). The seeds of soybean variety 'Pusa 9712' inoculated with *Rhizobium* culture as per treatments were sown in 45 cm rows using hand plough at a depth of 5 cm during second week of July with the onset of monsoon rains. The plants were thinned to maintain an intra-row spacing of 5 cm at 15 days after sowing (DAS).The crop was hand weeded 2 times at 30 and 60 DAS to keep it free from weeds. The crop was given 2 irrigations to tide over the dry spells during the crop growing period. No plant protection measures were used as crop was reasonably free from insecty-pests and diseases. Observations on growth and yield attributes were recorded from 5 plants selected randomly from the net plots while the seed and stover yields were recorded from the net plots at harvest as kg/ha. The harvest index was computed by dividing the seed yield by above ground biomass and expressed as percentage. All the data recorded were analyzed as per the analysis of variance technique (ANOVA) for factorial randomized block design and the treatments were compared for significance at 0.05 probability (Cochran and Cox, 1967)

RESULTS AND DISCUSSION

Growth attributes

The growth attributes were significantly affected by different treatments tried in the experiment (Table 1). The *Rhizobium* inoculation increased the plant height, number of branches and dry matter accumulation per plant significantly over un-inoculated control. The increasing levels of nitrogen increased these growth attributes upto 40 kg N/ha. The plant height, however increased significantly only upto 20 kg N/ha and it was at par with 40 kg N/ha. However, the number of branches and dry matter accumulation increased with each incremental dose of nitrogen upto 40 kg N/ha. The increasing levels of potassium also increased the growth attributes upto 40 kg K_2O /ha. The number of branches and dry matter accumulation increased significantly with each incremental dose upto 20 kg K_2O/ha.

There were significant interaction effects between *Rhizobium* inoculation and potassium levels and between levels of nitrogen and potassium on dry matter accumulation at different stages of growth (Table 2). At 30 DAS, the treatment combination of seed inoculation with *Rhizobium* along with 20 kg K_2O /ha recorded significantly higher dry matter

Table 1. Growth and yield attributes at harvest, seed and stover yield and harvest index of soybean as influenced by *Rhizobium* inoculation and levels of nitrogen and potassium (mean of 2 years)

Treatment	Plant height (cm)	Branches /plant	Dry matter	Pods/ plant (g/ plant)	Pod yield	Seed yield (g/ weight)	100 seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/h)	Harvest index (%)
Rhizobium										
Control	40.05	28.24	8.10	48.10	15.50	10.06	11.72	1187	3189	26.99
Inoculated	43.08	32.17	9.51	50.56	18.93	12.67	11.81	1387	3576	27.83
CD at 5%	1.49	0.98	0.30	1.62	1.55	1.43	NS	40	143	0.72
N levels (kg N/ha)										
0	38.95	24.90	7.46	44.01	13.40	8.78	10.98	977	2676	26.64
20	42.45	31.45	9.09	50.47	18.27	12.61	11.99	1391	3682	27.38
40	43.31	34.35	9.90	53.50	19.98	14.21	12.33	1492	3791	28.20
CD at 5%	1.82	1.20	0.37	1.99	0.67	0.52	0.38	48	175	0.88
K levels (kg K_2O/ha)										
0	39.90	27.25	7.76	45.08	15.51	10.47	11.45	1121	3067	26.63
20	42.11	31.21	9.31	50.75	17.83	12.52	11.88	1358	3516	27.80
40	43.80	32.16	9.34	51.43	18.30	12.61	11.96	1380	3566	27.80
CD at 5%	1.82	1.20	0.37	1.99	0.67	0.50	0.38	48	175	0.88

Table 2. Interaction between potassium levels with *Rhizobium* and nitrogen levels on the dry matter (g/plant) accumulation at different stages of crop growth (mean of 2 years)

Treatment	Potassium levels (kg K_2O /ha)		
	0	20	40
30 DAS			
Rhizobium			
Control	2.27	2.38	2.66
Inoculated	2.61	2.70	2.66
CD at 5%		0.18	
Nitrogen (kg N/ha)			
0	2.08	2.41	2.56
20	2.58	2.49	2.58
40	2.68	2.75	2.75
CD at 5%		0.22	
60 DAS			
Rhizobium			
Control	4.19	5.04	5.17
Inoculated	4.88	6.24	6.42
CD at 5%		0.30	
At harvest			
Nitrogen (kg N/ha)			
0	5.79	8.25	8.33
20	8.53	9.34	9.41
40	8.97	10.34	10.28
CD at 5%		0.64	

accumulation over treatment combinations of un-inoculated control with 0 and 20 kg K_2O/ha, while the rest of the treatment combinations were at par with each other. Further, the combination of 20 kg K_2O/ha and 40 kg N/ha recorded the highest dry matter at this stage and it was significantly superior to all treatment combinations except 40 kg N/ha with 0 and 40 kg K_2O/ha with which it was at par. At 60 DAS, the treatment combination of *Rhizobium* inoculation and 40 kg K_2O/ha recorded the highest dry matter accumulation and was significantly superior to all treatment combinations except *Rhizobium* inoculation and 20 kg K_2O/ha with which it was at par. At harvest, the treatment combination of 40 kg N/ha and 20 kg K_2O/ha recorded the highest dry matter accumulation. It was significantly higher to all other treatment combinations except the treatment combination of 40 kg N/ha and 40 kg K_2O/ha.

Yield attributes

Inoculation with *Rhizobium* culture recorded significantly higher number of pods, pod yield and seed yield per plant as compared to un-inoculated control. However, the test was not influenced significantly by the *Rhizobium* inoculation. Application of nitrogen at 40 kg/ha recorded significantly higher number of pods, pod yield and seed yield per plant as compared to 0 and 20 kg N/ha. Although, it also recorded the highest seed, it was at par with 20 kg N/ha. Both 20 and 40 kg N/ha recorded significantly higher index as compared to no nitrogen application. All the yield attributes studied recorded higher values with 40 kg K_2O/ha. However, both 40 and 20 kg K_2O/ha being at par with each other were significantly superior to no potassium application.

Yield and harvest index

The seed yield, stover yield and harvest index were significantly higher with *Rhizobium* inoculation as compared to un-inoculated control. This may attributed to improved nodulation supplying higher amount of nitrogen for growth and yield attributes which inturn helped to realize higher yield of both seed and stover. Similar observations were also made by Dubey *et al.* (1995). The highest seed yield, stover yield and harvest index were recorded with 40 kg N/ha. The seed yield was significantly higher as compared to both 0 and 20 kg N/ha, while the stover yield with 40 kg N/ha was at par with 20 kg N/ha and both were significantly superior to no nitrogen application. The harvest index also exhibited the similar trend as that of stove yield. The higher seed yield, stover yield and harvest index with 40 kg N/ha may be due to the fact that soybean requires higher nitrogen than supplied by the biological nitrogen fixation which seizes to exist after flowering stage. It may also be due to vigorous growth in terms of yield attributes and accumulation of nitrogen in plant tissues, which might have been diverted to pod development in later stages. This is in conformity with the findings of Ramesh *et al.* (2002). The increasing levels of potassium too increased the seed yield, stover yield and harvest index upto 40 kg K_2O/ha. However, the stover yield and harvest index with 20 and 40 kg K_2O/ha were at par with each other, while seed yield was significantly superior with 20 kg K_2O/ha. The potassium is an essential element having a role in many physiological functions of plants. The enhanced availability of this helps the plant to carry out physiological functions more efficiently and results in higher growth and yield attributes and seed yield of crop. Such effect of potassium were also reported by Mausami Raychaudhuri and Kailash Kumar (1998). Due to increased harvest index, stover yield did not increase significantly as compared to seed yield at 40 kg K_2O/ha.

On the basis of findings of this experiment it may be inferred that the inoculation with *Rhizobium* along with application of 40 kg N and 40 kg K_2O/ha will be helpful in increasing the growth and yield of soybean in medium fertile sandy loam soils in northern plain zone of India.

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EVALUATION OF RICE HYBRIDS FOR HETEROSIS OVER LOCATIONS

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ABSTRACT

One hundred and fifteen hybrids developed by utilizing five CMS lines and 23 testers were evaluated for extent of heterobeltiosis and standard heterosis in ten characters under irrigated conditions during *kharif* 2007 over three locations in Andhra Pradesh. Pooled standard heterosis for grain yield plant^{-1} was manifested through panicle weight, number of filled grains panicle^{-1} and productivity day^{-1}. Negative standard heterosis was observed for days to 50% flowering due to earliness in six hybrids for earliness over standard checks KRH 2 and PA 6201. Six crosses viz., APMS 6A x 1005, PUSA 6A x GQ-25, PUSA 5A x IR 43, APMS 6A x SC5 9-3 and PUSA 5A x KMR-3 were identified as potential hybrids with more than 28% standard heterosis for grain yield over high yielding commercial hybrid check KRH2. As these hybrids were already screened for suitability, they may be exploited for heterosis profitably.

Key words : Heterosis, locations, rice.

The exploitation of hybrid vigour is an appropriate alternative for making further break through in rice yield. A hybrid yield over high yielding check varieties and wider adaptability has been instrumental in rapid spread of hybrid rice in India. Yield is a cumulative function of various compnents. The contribution of components of yield are through component compensation mechanism. Hybrid vigour of even small magnitude for individual component may result in significant hybrid vigour for yield *per se*. Commercial exploitation of heterosis in rice today is profitable proposition. In this regard, it is obviously important that the crosses are compared with released hybrids rather than merely comparing with their mid or better parent. So in the present study the performance of the experimental crosses were compared with that of the most popular released hybrids *viz.*, KRH 2 and PA 6201 in order to estimate the magnitude of standard heterosis so that the crosses with high heterotic potential could be isolated for further evaluation and commercial cultivation.

MATERIALS AND METHODS

One hundred and fifteen CMS based hybrids, 23 restorer parents, 5 CMS lines and two checks (*viz.*, KRH 2 and PA 6201) were evaluated during kharif, 2007 at three different locations *viz.*, Directorate of Rice Research, Hyderabad (Southern Telangana agro- climatic zone), Regional Agricultural Research Station, Warangal (Central Telangana agro- climatic zone) and Regional Agricultural Research Station, Jagtial (Northern Telangana agro- climatic zone). All the entries at the age of 28 days were transplanted in randomized complete block design with two replications. Each entry was planted in two rows of 1.8 m length. Single seedling was transplanted per hill by adopting a spacing of 20 x 15 cm and all recommended package of practices were followed to raise a healthy crop. Observations were recorded for yield and its attributes such as plant height, flag leaf length, productive tillers per plant, panicle length, panicle weight, number of filled grains per panicle, spikelet fertility percentage, 1000 seed weight, grain yield per plant and productivity per day on five plants of each entry in each replication. Days to 50 per cent flowering was recorded on plot basis. The pooled mean value over three locations for each parent and hybrid was taken for computation of heterobeltiosis and standard heterosis over KRH2 and PA 6201 using standard methods.

RESULTS AND DISCUSSION

Positive and negative heterosis was observed for all the growth and yield attributing traits (Table 1). Early maturing hybrids are desirable as they produce more yields per day and fit well in multiple cropping systems. Among the 115 hybrids, 13 hybrids exhibited significant negative heterobeltiosis over their respective better parents in pooled analysis. Six hybrids viz., IR 58025A x BR 827-35, IR 58025A x EPLT 109, IR 79156A x IBL-57, PUSA 5A x IR 60 and CRMS 32A x IBL-57 were significantly heterotic for earliness over standard checks KRH 2 and PA 6201.The early flowering in hybrids has been reported earlier (Mishra and Reddy, 1998). Shorter plant type is an important character of a hybrid to withstand lodging. All the hybrids were taller than their better parents and hence exhibited significant positive heterobeltiosis. The significant reduction in plant height was observed in six hybrids viz., CRMS 32A x IR 43, PUSA 5A x IR 60, PUSA 5A x IR 55, PUSA 5A x 517, PUSA 5A x EPLT 109 and IR 79156A x GQ-25 over standard check PA 6201. Negative standard heterosis estimates for plant height were reported by Virmani *et al.*, 1982.

Higher flag leaf length is a desirable feature of hybrid rice for efficient photosynthesis at and after flowering. For this trait, as many as 22 hybrids registered significant positive heterobeltiosis ranging from 10.79 to 37.60 per cent. Fifty seven hybrids registered significant positive standard heterosis over KRH 2 and P A 6201. Two hybrids CRMS 32A x SC5 9-3 and CRMS 32A x IBL-57 were found to be highly consistent with significant positive heterobeltiosis and standard heterosis at all the three locations tested. Many other hybrids were inconsistent in their superiority with respect to heterobeltiosis and standard heterosis over the

Table 1a. Pooled analysis of variance for combining ability (L X T) for yield and yield components in rice

Source of variation	d.f.	Days to 50% flowering	Plant height	Flag leaf length	Flag leaf width	Productive tillers/plant	Panicle length
Locations	2	8166.540 **	6484.604 **	6451.716 **	6.618 **	86.747 **	202.405 **
Replications x Locations	2	4.938	29.056	0.375	0.134 **	0.175	0.379
Treatments	142	63.697 **	336.490 **	80.313 **	0.175 **	12.895 **	11.118 **
Parents	27	105.061 **	805.453 **	81.219 **	0.256 **	2.885 **	10.987 **
Parent vs.Crosses	1	42.894 **	1930.397 **	1593.886 **	0.203 **	1058.221 **	514.087 **
Crosses	114	54.083 **	211.438 **	66.821 **	0.155 **	6.097 **	6.737 **
Lines	4	39.357	394.483	245.108 **	0.870 **	10.618 *	19.280 **
Testers	22	71.607	372.022 **	109.044 **	0.189	13.195**	10.127 *
Lines x Testers	88	50.371 **	162.972 **	48.162 **	0.114**	4.116 **	5.319 **
Parents x Locations	54	33.297 **	92.719 **	40.486 **	0.095 **	2.260 **	3.337 **
(Parent vs. Crosses) x Locations	2	597.974 **	858.389 **	81.341 **	0.030	26.055 **	37.831 **
Crosses x Locations	228	54.380 **	87.636 **	42.938 **	0.079 **	4.269 **	2.818 **
Lines x Locations	8	42.079	130.372	200.827 **	0.289 **	10.170 *	1.735
Testers x Locations	44	65.061	91.173	47.957	0.090	4.533	2.515
Lines x Testers x Locations	176	52.269 **	84.809 **	34.506 **	0.067 **	3.935 **	2.943 **
Error	426	3.812	9.963	8.677	0.021	0.967	0.79

*: Significant at 5% level and **: Significant at 1 % level

Table 1b. Pooled analysis of variance for combining ability (L X T) for yield and yield components in rice

Source of variation	d.f	Panicle weight	Filled grains per pacnicle	Spikelet fertility %	1000 grain weight	Grain yield per plant	Produc tivity per day
Locations	2	10.027 **	12805.560 **	4297.021 **	34.324 **	876.645 **	4823.378 **
Replications x Locations	2	0.268	160.089	0.282	0.221	1.522	12.162
Treatments	142	3.027 **	7583.527 **	119.148 **	25.561 **	160.233 **	714.219 **
Parents	27	1.932 **	6297.925 **	79.294 **	40.342 **	52.871 **	240.599 **
Parent vs.Crosses	1	98.811 **	100092.800**	375.922 **	51.517 **	4458.350 **	20275.250 **
Crosses	114	2.446 **	7076.527 **	126.335 **	21.832 **	147.958 **	654.804 **
Lines	4	21.533 **	49802.710 **	312.097 *	21.425	503.279 **	1960.378 *
Testers	22	2.359	9377.320 **	165.686	54.209 **	156.382	711.171
Lines x Testers	88	1.600 **	4559.229 **	108.053 **	13.756 **	129.701 **	581.368 **
Parents x Locations	54	0.829 **	1856.914 **	60.818 **	9.070 **	30.227 **	139.273 **
(Parent vs. Crosses) x Locations	2	3.983 **	13293.420 **	104.211 **	42.976 **	150.846 **	545.955 **
Crosses x Locations	228	0.935 **	2449.021 **	98.394 **	13.826 **	68.936 **	319.323 **
Lines x Locations	8	1.043	3146.987	190.423	17.752	82.201	357.870
Testers x Locations	44	1.131	2587.760 **	85.863	16.059	62.670	297.621
Lines x Testers x Locations	176	0.882 **	2382.610 **	97.344 **	13.089 **	69.899 **	322.996 **
Error	426	0.152	138.777	6.252	0.390	3.688	16.505

*: Significant at 5% level and **: Significant at 1 % level

locations (Mishra and Pandey (1998) and Yadav *et al.*, 2004)

Number of prodictive tillers per plant is known to directly contribute towards grain yield. Hundred and two hybrids recrored positive significant hetrrobeltions while, seven hybrids viz, IR 79156A x IBL-57, APMS 6A x 612-1, APMS 6Ax GQ 37-1, APMS 6A x SC5 9-3, APMS 6A x 124, PUSA 5A x 1096 and CRMS /' GQ 37-1 exhibited significant positive standard heterosis over KRH 2 and PA 6201. (Singh *et al.*, 2006 and Deoraj *et al.*, 2007).

Longer panicle is generally associated with more number of spikelets and this is one of the attributes for higher grain yields in rice hybrids. For this trait, 68 hybrids recorded significant positive heterobeltiosis. Five hybrids viz., IR 79156A x SG 26-120, IR 79156A x 124, APMS 6A x 612-1, APMS 6A x GQ-120 and CRMS 32A x 612-1 were found to be highly consistent with significant positive standard heterosis over both the standard checks KRH 2 and P A 6201 at all the three locations tested. Panicle weight is positively associated with grain yield and as many as 71 hybrids manifested significant positive heterobeltiosis ranging from 13.12 per cent (PUSA 5A x KMR-3) to 77.80 per cent (APMS 6A x 1005). Forty six and fifty six crosses ~ excelled superiorly in desirable direction over KRH 2 and PA 6201, respectively. (Lokaprakash *et al.*, 1992 and Ghosh, 2002). Number of filled grains per panicle is one of the most important components of yield. Fifty four hybrids showed significant increase in number of filled per panicle over KRH 2, Where two over PA 6201. (Deoraj *et al.*, 2007, Rosamma and Vijayakumar, 2007 and Singh *et al.*, 2007).

Table 2. Heterosis of some promising hybrids for grain yield per plant and its components in rice.

	Flag leaf lenl th			Days to 50% flowerin!			Plant bei2ht			Panicle len2th		
	HB	SH1	SH2	HB	SH1	SH2	HB	SH1	SH2	HB	SH1	SH2
APMS 6A x 1005	-5.98	25.33 ··	13.14 ··	3.43 o	7.65 **	8.21	9.78 ··	-4.48 o	0.79	4.38	-5.41	-2.95
APMS 6A x 612-1	2.25	36.30 ··	23.04 **	-3.17	-1.19	-0.68	29.72 oo	12.88 ··	19.11 oo	10.57 ·	3.90 o	6.60 ··
APMS 6A x OQ-25	1.96	35.92 ··	22.70 ··	2.04	2.04	2.56	14.39 ··	-0.47	5.03 ··	4.85	-4.99 ··	-2.52
APMS 6A x 00-120	-8.88 o	21.47 ··	9.65	-1.01	0.17	0.68	30.30 ··	13.38 ··	19.63 ··	16.50 ·	5.57 ··	8.31
APMS 6A x SC5 9-3	5.80	41.05 ··	27.32 ··	0.33	4.42 ··	4.96 ··	11.79 ··	-2.72	2.64	6.11	0.52	3.13
APMS 6Ax S026-120	0.52	34.01**	20.97 "'*	3.95 ··	2.89 o	3.42 ··	19.46 ··	3.94	9.68 ··	4.70	1.44	4.07
APMS 6A x 118	-18.88 ··	8.14	-2.38	-5.23 ··	-1.36	-0.85	22.53 ··	6.62 ··	12.50 ··	8.00 ··	0.28	2.88
APMS6A x 517	0.00	33.30 ··	20.33 ··	3.76 ··	7.99 ··	8.55 ··	12.83 ··	-1.82	3.60 o	6.04 ··	-3.91	-1.41
IR 58025A x OQ-37-1	10.79 o	18.71	7.16	5.49 ··	1.36	1.88	33.46 ··	5.58 ··	11.40 ··	12.79 ··	3.66	6.36 ··
IR 79156A x KMR-3	5.98	35.57 ··	22.38 ··	4.67 ··	-0.85	-0.34	19.70 ··	5.31	11.12**	7.47	3.59	6.28 ··
IR 79156A x IBL-57	-6.37	19.77 ··	8.12	1.62	-3.74 ··	-3.25 ··	16.36 ··	0.59	6.15 ··	2.46	-1.25	1.32
IR 79156A x S027-77	3.28	32.12 ··	19.27 ··	7.36 ··	1.70	2.22	21.34 ··	6.76 ··	12.65 ··	2.71	2.32	4.97
CRMS 32A x IBL-57	37.60 ··	47.46 ··	33.11	-6.41	-3.23 ··	-2.74	15.55	-4.39	0.88	6.09 ··	-5.21	-2.75
	8.31	25.03 ··	12.86 ··	5.10	5.64 ··		5.47 ··	11.29	13.61	1.50	4.14	
CRMS 32A x 517					1.64			27.47 ··				
PUSA 5A x IR 43	1.37	15.63 ··	4.38	-0.32	4.59 ··	5.13	27.42 ··	-3.09	2.26	11.90 ··	-4.90 o	-2.43
PUSA 5A x IR55	-0.35	13.68 o	2.62	-3.89 ··	0.85	1.37	6.47 ··	-11.92 ··	-7.05	-0.35	-7.80 ··	-5.41
PUS A 5A x 1096	2.64	24.51 oo	12.40 o	-1.78	3.06 ··	3.59 ··	24.05 ··	2.63	8.30 ··	13.53 ··	0.32	2.93
PUSA5A x 124	2.78	17.25 ··	5.84	-1.62	3.23 oo	3.76 ··	26.22 ··	4.42 o	10.19 ··	4.78 o	-2.90	-0.38
PUSA 5A x KMR-3	6.89	21.93 ··	10.07 o	-7.13 ··	-2.55 o	-2.05	29.67 ··	7.28 ··	13.20 ··	2.26	-1.61	0.94
PUSA 5A x S027-77	-4.87	20.82 ··	9.07	-5.02 ··	-0.34	0.17	26.29 ··	4.48 o	10.24 ··	2.98	2.59	5.25 ··
Heterosis range	-24.25 to 37.60	-7.41 to 50.33	-16.42 to 35.70	-7.13 to 14.34	-4.76 to 9.86	-4.27 to 10A3	1.03 to 39.59	-15.81 to 15.55	-11.17to 21.93	-7.86 to 16.50	-11.54 to 6.37	-9.24 to 9.13
+ ve significant	22	103	57		54	62		34	81	68	5	29
- ve significant	18	0	0		9	6		25	6	4	5	29
Top five crosses	IR 79156A X 00-120 CRMS32A X SC5 9-3 CRMS32A X IBL 57 IR 79156A X 1096 IR 79156A X 00-7			PUSA 5A X IR 60 IR 58025A X BR 827-35 IR 79156A X IBL 57 CRMS32A X IBL 57 IR 79156A X 00 70			CRMS32A X IR 43 PUSA 5A X IR 60 PUSA5AX517 PUSA 5A X IR 55 IR 79156A X EPLT-I09			IR 79156A X 124 IR 79156A X SO 26-120 APMS 6A X 00-120 CRMS32AX612-1 APMS 6A X 611-1		

HB= Heterobeltiosis, SH1 = Heterosis over KRH2, SH2= Heterosis over PA 6201; *& ** singnificant at 5% and 1% lwvels, respectively.

Table 2. Contd..

	Panicle weight			Productive tillers per plant			Fklled grains per spikelet			Spikelet fertility %		
	HB	SH1	SH2	HB	SH1	SH2	HB	SH1	SH2	HB	SH1	SH2
APMS 6A x 1005	77.80 **	50.27 **	55.53 **	32.58 **	1.20	-1.83	32.58 **	1.20	-1.83	4.38 *	-5.41 **	-2.95
APMS 6A x 612-1	25.51 **	18.48 **	22.63 **	44.15**	21.02 **	17.39 **	44.15 **	21.02 **	17.39 **	10.57 **	3.90 *	6.60 **
APMS 6A x OQ-25	48.26 **	36.28 **	41.04 **	42.84 **	9.03	5.76	42.84 **	9.03	5.76	4.85 *	-4.99 **	-2.52
APMS 6A x 00-120	27.40 **	8.63	12.42 *	38.37 **	5.62	2.45	38.37 **	5.62	2.45	16.50 **	5.57 **	8.31 **
APMS 6A x SC5 9-3	36.84 **	57.36 **	62.86 **	49.80 **	19.42 **	15.84 **	35.10 **	58.15 **	56.55 **	-4.45 **	-1.92	5.36 **
APMS 6Ax S016-120	39.10 **	17.56 **	21.68 **	37.75 **	13.09 *	9.70	25.29 **	17.17 **	15.99 **	-6.17 **	-0.45	6.94 **
APMS6A x 118	26.96 **	52.04 **	57.36 **	41.81 **	8.25	5.00	29.83 **	54.70 **	53.14 **	-2.13	-0.83	6.53 **
APMS6A x 517	8.03	13.76 *	17.74 **	13.90 *	-13.06 *	-15.67 **	9.48 *	16.10 **	14.93 **	-0.98	0.34	7.79 **
IR 58025A x 00-37-1	-10.01	-4.82	-1.50	23.90 **	0.12	-2.88	-30.67 **	-10.98 **	-11.88 **	-3.32 *	-3.56 *	3.60 *
IR 79156A x KMR-3	11.98	-1.10	2.36	43.61 **	23.24 **	19.54 **	2.46	-9.49 *	-10.41 *	0.92	0.74	8.21 **
IR 79156A x IBL-57	33.38 **	-1.12	2.33	41.43 **	12.90 *	9.51	-3.92	13.45 **	12.31 **	4.03 *	-0.08	7.33 **
IR 79156A x S027-77	27.73 **	26.42 **	30.84 **	26.93 **	1.32	-1.71	19.55 **	37.06 **	35.68 **	2.77	2.99	10.63 **
CRMS 32A x mL-57	46.22 **	24.17 **	28.52 **	29.91 **	6.66	3.46	4.81	23.76 **	22.51 **	0.49	1.45	8.98 **
CRMS 32A x 517	32.39 **	39.42 **	44.30 **	21.46 **	-0.28	-3.27	41.30 **	49.84 **	48.33 **	3.00	3.99 *	11.71 **
PUSA 5A x IR 43	20.73 **	-7.22	-3.98	17.01*	-7.90	-10.66*	15.59 **	-12.37 **	-13.26 **	-0.83	-4.30 **	2.80
PUSA 5A x IR55	13.14	-6.04	-2.75	15.86 *	-8.81	-11.54 *	24.31 **	-13.92 **	-14.79 **	-9.33 **	-12.50 **	-6.01 **
PUSA 5A x 1096	32.01 **	32.44 **	37.08 **	60.29 **	26.16 **	22.38 **	23.49 **	31.87 **	30.54 **	0.15	-2.56	4.67 **
PUSA 5A x 124	3.68	-8.00	-4.78	18.50 **	-6.73	-9.53	10.84 *	-0.19	-1.19	5.06 **	1.38	8.91 **
PUSA 5A x KMR-3	13.12 *	-0.10	3.39	30.82 **	12.26 *	8.89	-1.57	-13.06 **	-13.94 **	-5.00 **	-5.17 **	1.87
PUSA 5A x S027-77	-0.73	-1.74	1.69	33.48 **	5.07	1.92	-3.17	10.71 **	9.59 *	-3.07	-2.86	4.35 *
Heterosis range	-27.98 to 77.80	-23.83 to 57.36	-21.16 to 62.86	-5.64 to 60.29	-23.76 to 26.16	-26.04 to 22.38	-41.11 to 82.26	-33.40 to 80.46	-34.07 to 78.64	-22.58 to 6.31	-21.84 to 5.61	-16.04 to 13.45
+ ve significant	71	46	56	102	14	7	61	54	52	14	3	66
- ve significant	7	10	5	0 12	20	18	29	34	61	54	20	
Top five crosses	APMS 6A X SC5 9-3 APMS6AX 118 APMS 6A X 1005 CRMS 32 A X 517 APMS 6A X SC5 2-2-1			PUSA 5A X 1096 IR 79156A X KMR-3 APMS 6A X SC5 9-3 CRMS32A X GQ 37-1 APMS 6A X 124			APMS 6A X 1005 APMS 6A X SC5 9-3 APMS6AX 118 CRMS 32 A X 517 CRMS 32 A X 00-70			CRMS 32 A X 00-70 CRMS 32 A X 517 APMS 6AX 124 CRMS 32 A X KMR-3 IR 79156A X SO 26-120		

HB= Heterobeltiosis, SH1 = Heterosis over KRH2, SH2= Heterosis over PA 6201; *& ** singnificant at 5% and 1% lwvels, respectively.

Table 2. Contd..

	Productivity per day			Grain yield per plant			Grain yield per plant	
	HB	SH1	SH2	HB	SH1	SH2	Mean perfor mance	sca
APMS 6A x 1005	83.89··	22.91··	32.93··	88.28··	29.90··	40.98 oo	36.44'''''	7.56 ·'''
APMS 6A x 612-1	61.30··	24.51 oo	34.65 '''.	58.59 ·'''	23.34··	33.86··	34.60 ·'''	6.99'''''
APMS 6A x 00-25	74.12 oo	33.92··	44.83··	77.48 '''.	36.54 ·'''	48.18 oo	38.31 ·'''	10.49**
APMS 6A x 00-120	56.84··	11.52··	20.60··	54.75 '''''	11.32··	20.81 oo	31.23'''·	4.68
APMS 6A x SC5 9-3	56.23··	24.97 '''.	35.15··	56.21··	28.93··	39.93··	36.17'''''	7.63**
APMS 6Ax S026-20	48.90 ·'''	8.58 o	17.42··	54.28 ·'''	11.39 '''''	20.89··	31.25**	1.80
APMS6A x 118	52.87··	14.56··	23.90 oo	47.65··	13.57··	23.25 oo	31.86'''''	3.57**
APMS6A x 517	56.05··	4.30	12.80 oo	61.95 ·'''	11.74 '''''	21.27··	31.35'''''	3.01
IR 58025Ax 00-37-1	22.99 '''.	10.03 o	19.00 ·'''	26.33··	11.64··	21.16 '''.	31.32**	6.82**
IR 79156A x KMR-3	46.02 ·'''	18.43 .'''	28.08 '''''	39.48 *.	16.44 ·*	26.37 *'''	32.67'''''	5.01'''''
IR 79156A x IBL-57	97.33··	19.61 *.	29.36··	87.46··	18.04··	28.11 oo	33.12'''''	7.55'''''
IR 79156Ax S027-77	82.88··	21.64 ·*	31.55··	74.53 ·'''	23.86 **	34.43 **	34.75'''''	5.96'''''
CRMS 32A x IBL-57	45.61 **	19.24 oo	28.95 **	33.64 **	16.68 **	26.64 **	32.74**	3.02
CRMS 32A x 517	36.53 oo	11.80 .*	20.91 oo	32.54 oo	15.71 oo	25.59 oo	32.46'''*	3.85**
PUSA 5A x IR 43	119.13**	20.08 oo	29.86 oo	108.10 oo	23.28 ·*	33.80 **	34.59'''''	10.08'''*
PUSA 5A x IR55	72.01 **	12.60 ·*	21.78 *.	65.38 oo	13.07 oo	22.71 oo	31.72'''''	7.89'''''
PUSA 5A x 1096	36.69··	14.27 **	23.58 oo	33.57 oo	16.91 **	26.89 **	32.80'''''	4.45*'''
PUSA 5A x 124	56.82 ·*	8.91 *	17.78 oo	54.91 oo	11.53 **	21.05··	31.29'''''	3.06
PUSA 5A x KMR-3	70.51 **	38.30 **	49.57 **	62.65 **	35.77 **	47.36 **	38.09**	7.10'''''
PUSA 5A x S027-77	74.90 **	16.33 **	25.81 oo	64.55 **	16.78 **	26.74 **	32.76'''''	0.65
Heterosis range	-21.73 to 119.13	-41.78 to 38.30	-37.04 to 49.57	-19.46 to 88.28	-42.28 to 36.54	-37.35 to 48.18	CDat5% =3.76	SEij= 0.81
+ ve significant	71	20	37	72	23	42		
- ve significant	12	56	34	II 53	35			
Top five crosses	PUSA5A X KMR-3 APMS 6A X 00025 APMS 6A X SC5 9-3 APMS 6A X 612-1 APMS 6A X 1005			APMS 6A X OQ-25 PUSA5A X KMR-3 APMS 6A X 1005 APMS 6A X SC5 9-3 IR 79156A X SO 27-77				

Low• gram yields in .rice hybrids are attributed mainly to the high sterility percentage. The extent of spike let fertility directly influences the ultimate product (grain yield). Most of the hybrids exhibited negative heterosis at all the locations for this trait. Fourteen hybrids had significant positive heterobeltiosis. Only three hybrids viz., CRMS 32A x GQ-70 (5.61%), CRMS 32A x 517 (3.99%) and APMS 6A x 124 (3.51%) registered significant positive standard heterosis over KRH 2. (Panwar *et al.*, 2002). Hundred grain weight of a genotype serves as an indicator to the end product i.e., grain yield. Over their better parents 31 and 53 hybrids significantly higher and lower test weights, respectively.Thirty three and 52 hybrids shows significantly more standard heterosis over KRH 2 and PA 6201, respectively. (Eradasappa *et al.*, 2007; Rosamma and Vijayakumar, 2007 and Singh *et al.*, 2007). Productivity per day is an important character for higher yield in shorter time, 71 hybrids could manifest significant positive heterobeltiosis ranging from 9.10 to 119.13 per cent. Twenty hybrids over KRH 2 thirty seven hybrids over P A 6201 showed significant positive standard heterosis. Hossain *et al.* (2005) in their studies observed significant positive heterosis for productivity per day.

The present investigation revealed a high order of heterosis for grain yield per plant. 72 hybrids manifested significant positive heterobeltiosis ranging from 9.71 per cent (CRMS 32A x SC5 2-2-1) to 88.28 per cent (APMS 6A x 1005). Twenty three over KRH 2 and forty two over PA 6201 registered significant positive standard heterosis in pooled analysis. The hybrid which exhibited highest heterosis over KRH2 and PA 6201, was APMS 6A x GQ-25 (36.54% and 48.18%) followed by PUSA 5A x KMR-3 (35.77% and 47.36%), APMS 6A x 1005 (29.90% and 40.98%), APMS 6A x SC5 9-3 (28.93% and 39.93%)

and IR 79156A x SG 27-77 (23.86% and 34.43%). Heterobeltiosis and standard heterosis of both positive and negative nature for grain yield per plant was reported by, Deoraj *et al.* (2007) , Eradasappa *et al.* (2007), Rosamma and Vijayakumar (2007) and Singh *et al.* (2007).

Grain yield per plant is a multiplicative product of several basic components of yield. The increased grain yield is definitely because of increase in one or more than one yield components. In the above crosses the superiority of hybrids in grain yield was through number of filled grains per panicle, panicle weight and productivity per day. The major reason for the high degree of heterosis was due to genetic divergence in the parents, though the predominance of dominant gene action was operating in the inheritance of the traits, as explained by Virmani et al. (1982) Among these top five crosses, APMS 6A x GQ-25 also registered significant positive standard heterosis for productivity per day, IOOO-grain weight, filled grains per panicle and panicle weight, PUSA 5A x KMR-3 for productivity per day and 1000-grain weight, both APMS 6A x 1005 and APMS 6A x SC5 9-3 for productivity per day, filled grains per panicle and IR 79156A x SG 27-77 for filled grains per panicle. This indicates that the yield attributes helped the hybrids to get high heterosis for grain yield per plant. Similarly other hybrids which manifested significant standard heterosis for this trait were: APMS 6A x 612-1, PUSA 5A x KMR-3, IR 79156A x IBL-57, PUSA 5A x 1096 and PUSA 5A x SG 27-77 and were also supported by different quantitative traits with significant standard heterosis.

Five cross combinations viz., APMS 6A x 1005, PUSA 6A x GQ-25, PUSA 5A x IR 43, APMS 6A x SC5 9-3 and PUSA 5A x KMR-3 have been identified as promising. The cross APMS 6A x 1005 possessed high per se performance (36.44 g), significant positive sea effect (7.56) and standard heterosis of 29.90 per eent over the best check KRH 2 for grain yield per plant. Besides grain yield, the cross also showed high per se performance, significant positive sea effects and standard heterosis for other yield contributing characters like panicle weight, filled grains per panicle and productivity per day.

The cross APMS 6A x GQ-25 exhibited significant positive sea effect (10.49) and standard heterosis (36.54%) along with the high per se performance of 38.31 g for grain yield per plant. The cross was also promising for panicle weight, filled grains per panicle and productivity per day. The cross PUSA 5A x IR 43 was found to be good with sigificant positive sca effect (10.08) abd standard heterosis (23.28%) along with the high per se performance of 34.59 g for grain yield per plant. Besides grain yield, the cross had shown promise for productivity per day.

The hybrids APMS 6A x SC5 9-3 and PUSA 5A x KMR-3 recorded high standard heterosis (28.93% and 35.77%) over KRH 2, significant positive sea effects (7.63 and 7.10) and high per se performance (36.17 g and 38.09 g) for grain yield per plant. Besides grain yield, the cross APMS 6A x SC5 93 was promising for panicle weight, filled grains per panicle and productivity per day, whereas, PUSA 5A x KMR-3 was promising for IOOO-grain weight and productivity per day.

The overall results of heterobeltisos and standard heterosis indicated that the parents involved in the crossing should have one high per se performing parent and over dominance may be the cause of heterosis. The main reason ascribed is diversified parents involved in the cross combinations or uncommon genes for a trait is the cause to exploit the maximum exploitable level of heterosis in rice. Different estimates show that in a self pollinated plant to be economically advantageous, hybrid must give atleast 20-25% higher grain yield than the best commercial variety available or 5-10% over hybrid variety. It can be clearly brought out that the five cross combinations viz., APMS 6A x 1005, PUSA 6A x GQ-25, PUSA 5A x IR 43, APMS 6A x SC5 9-3 and PUSA 5A x KMR-3 with more than 28% standard heterosis for grain yield over high yielding commercial hybrid check KRH-2 offer greater scope for exploitation of the hybrid vigour on commercial scale.

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PERFORMANCE OF FIELD PEA (*PISUM SATIVUM*) AS *UTERA* CROP IN RELATION TO GROWTH DURATION OF RICE (*ORYZA SATIVA*) UNDER RAINFED CONDITIONS

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Abstract

The experiment was conducted during 2001-02 and 2002-03 on the farmers field at 10 locations covering 2 farmers in each of the 5 villages of Dindori district of Madhya Pradesh. The performance of field pea as an *utera* crop with early maturing rice cv. 'IR-36' and 'Poonima' was the best. *Utera* cropping with traditionally grown rice variety proved to be less remunerative because of very low yield of rice as well as *utera* crop. The success of rice-based *utera* cropping system appears to be much assured under rainfed situations by growing suitable utera crop with early and medium duration rice varieties.

Key words : Pea, Rice, *Utera.*

Utera cropping is a conventional method of raising succeeding crop with the utilization of residual soil moisture left after the harvest of preceding rice under rainfed condition. It is prevalent in West Bengal, Orissa, Assam, Jharkhand, Chhattisgarh and Madhya Pradesh state of the country. Generally, *utera* crops are grown in low land rice fields of Kymore plateau and Satpura hills Zone of Madhya Pradesh under rainfed conditions as a second crop after rice. Cultivation of low yielding traditional long-duration rice varieties and locally available verities of *utera* crop with a little or no use of fertilizers appears to be the main reason for low productivity. Introduction of short duration, high yielding dwarf rice varieties in these areas could be helpful to minimize the crop span and to make efficient use of residual soil moisture for growing the succeeding *utera* crop (Sharma and Yasin, 1997; Singh and Verma, 1988). Keeping these points in view, a field experiment was conducted to identify suitable rice variety for successful cultivation of succeeding *utera* crops under rainfed conditions.

Materials and Methods

The experiments were conducted during 2001-02 and 2002-03 on the farmers field at 10 locations covering 2 farmers in each of the 5 villages of Dindori district of Madhya Pradesh. Soils are clay loam, having ph 5.7 to 5.9, available N, P_2O_5 and K_2O, 290-310, 11.3-16.4 and 263-283 kg/ ha, respectively. The seasonal rainfall received was 1373 and 821 mm during 2001-02 and 2002-03, respectively.

The experiment was laid out in a randomized block design with 10 replications (locations). The treatments comprised of four varieties of rice viz. T_1- commonly grown local variety (Badi Luchai) by the farmers (>130 days duration), T_2- recommended high yielding rice variety of the same duration as that of the farmers practices (Mahamaya), T_3-recommended high yielding variety of one week shorter (IR-36), T_4- recommended high yielding variety of two week shorter duration (Poornima). The field pea (cv.Local) as *utera* crop was broadcasted in standing rice crop at two weeks after flowering of each rice variety. Productivity of base crop rice and their succeeding *utera* crop was recorded. Finally, economics was computed for entire rice-based *utera* cropping system.

Results and Discussion

The result (Table 1) indicated that the improved high yielding rice variety (Mahamaya)

Table 1. Growth and yield attributes of rice under different treatments

Treatments (Variety of rice and growth duration)	Tillers/m²			Grains/ ear			1000 seed weight (g)			Yield * (q/ ha)		
	Y1	Y2	Mean	Y1	Y2	Mean	Y1	Y2	Mean	Y1	Y2	Mean
T_1- Rice variety commonly grown by the farmers i.e. Badi Luchai (>130 days)	252	235	243.5	65	61	63	24.5	24.7	24.6	18	17	17.5
T_2- Rice variety of the same duration as that of the farmers practices (Mahamaya)(<130 days)	310	297	303.5	82	73	77	25.3	25.1	25.2	41	38	39.5
T_3- Rice variety of one week shorter duration i.e. (IR-36) (120 days)	305	285	295.0	76	71	73	25.2	25.4	25.3	36	35	35.5
T_4- Rice variety of two week shorter duration i.e. (Poornima) 110 days).	275	261	268.0	72	69	70	24.7	24.9	24.8	32	29	30.5
CD (P=0.05)	-	-	-	5.2	6.1	5.5	-	-	-	3.3	3.1	2.9

Where, Y1 + Year 2001-02, Y2= Year 2002-03, *Cost of rice was Rs. 430/q

Table 2. Growth, yield attributes and net return from *utera* crop field pea under different treatments

Treatments	*Utera* crop of field pea (Cv. Local)															Net returns (Rs/ ha)		
	Branches/ plant at maturity			pods/ plant			Seeds/ plant			1000 seed wt. (g)			yield* (q/ha)					
	Y1	Y2	M	Y1	Y2	M	Y1	Y2	M	Y1	Y2	M	Y1	Y2	M	Y1	Y2	M
T_1	4	3	3.5	30	25	27.5	5	4	4.5	76.5	76.0	76.2	7.60	6.50	7.05	4420	2460	3440
T_2	6	5	5.5	37	35	36.0	5	5	5.0	77.1	76.6	76.8	8.20	7.60	7.90	17390	15020	16205
T_3	9	7	8.0	47	42	44.5	5	5	5.0	76.6	77.0	76.8	11.10	10.50	10.80	18510	17200	17855
T_4	7	6	6.5	43	40	41.4	5	4	4.5	765	75.9	76.2	10.50	9.10	9.80	15610	12200	13905
CD (P=0.05)	1.7	2.1	1.4	6.3	5.5	6.1	-	-	-	-	-	-	0.79	1.40	1.10	-	-	-

Where, Y1= Year 2001-02, Y2=Year 2002-03, M=Mean, * Cost of rice was Rs. 430/q of the same duration as that of the farmers traditional rice variety (Badi Luchai) was found to give significantly higher growth parameters and yield components. A late maturing improved variety of rice (Mahamaya) gave higher grain yield (39.5q/ha) and traditionally grown rice variety (Badi luchai) gave lower yield (17.5q/ha).

The result (Table 2.) indicate that performance of field pea as an *utera* crop with early maturing rice c.v. IR-36 (120 days) and Poornima (110 days) was the best. The grain yield of field pea in treatment T_3 and T_4 was 10.80 and 9.80 q/ha, respectively. Grain yields of *utera* crop was reduced, when field pea was grown with long- duration varieties of rice including local one (Siddiqui *et al.*,2000). *Utera* cropping with traditionally grown rice variety proved to be less remunerative (Rs. 3440/ ha) because of very low yield of rice (17.5q/ha) as well as *utera* crop (7.05 q/ah.)

These finding evidently indicate that the *utera* cropping of field pea was good with early, medium as well as late maturing rice variety in Dindori District of Madhya Pradesh (Singh and Verma, 1998). But success of rice based *utera* cropping system appears ot be much assured under fainfed situation by growing suitable *utera* crop with early and medium rice varieties due to efficient use of soil moisture even under early cessation of monsoon (Das and Das, 1988) and (Mondal *et al.*, 2004).

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STUDIES ON VARIABILITY, HERITABILITY AND GENETIC ADVANCE FOR MORPHOLOGICAL AND YIELD TRAITS IN BRINJAL (*SOLANUM MELONGENA* L.)

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ABSTRACT

Eighteen brinjal genotypes were studied for genetic variability, heritability and genetic advance for different morphological and yield contributing characters. The study revealed existence of considerable amount of genetic variability for all the characters except plant canopy. The number of fruits per plant exhibited highest values of Genetic Coefficient of Variance (GCV) and Phenotypic Coefficient of Variance (PCV) followed by fruit yield, fruit length, number of branches per plant, average fruit weight, however fruit width and plant height showed moderate GCV and PCV. High heritability values were observed for fruit yield, number of fruits/plant, fruit length and average fruit weight, interfering fruit yield and its related traits are reliable parameters for enhancing yield in brinjal. High values of heritability coupled with high genetic were observed for average fruit weight, number of fruits per plant, fruit yield, number of branches per plant and fruit length indicating that they can be used directly for selection in improvement of brinjal.

Key words : Variability, genetic advance, brinjal.

The exploration of genetic variability in the available germplasm is a pre-requisite in a breeding programme for effective selection superior genotype. The partitioning of total variability into heritable and non-heritable components by using suitable design will enable the breeders to know whether the superiority of selection is inherited by the progenies or not. Genetic variation for most of the morphological and yield attributes is considerably high in brinjal, there is a need of information on the nature and magnitude of variation available in the material and part played by environment in expression of different characters. Keeping in view the above facts, the present investigation was undertaken to estimate the magnitude of heritable and non-heritable component of variation and genetic parameters such as genetic coefficient of variation (GCV) heritability and genetic advance in 18 diverse genotypes of brinjal and work out their reliability for selection of superior plant type.

MATERIALS AND METHODS

The experiment was conducted at Vegetable Research Farm, Division of Vegetable Science and Floriculture, SKUAST-J, Chatha during summer season of 2006. Eighteen diverse genotypes of brinjal were tested for variability, heritability and genetic advance under Randomized Block Design with 3 replications. The plot size of 3x2 m was made to accommodate 15 plants at a spacing of 45x60 cm between plants and rows respectively. All the cultural practices were followed as per the recommendations (Anonymous, 2006). Five competitive plants per bed for each replication were tagged for taking observation. The data taken on eight characters *viz.* plant height (cm), number of branches per plant, canopy (cm), fruit lengh (cm), fruit weight (g), number of fruits per plant and fruit yield (q/ha) was subjected to statistical analysis as per the method of analysis of variance (Panse and Sukhatme, 1978). Genotypic and phenotypic coefficient of variances were calculated according to Hanson *et al.* (1956), however, genetic advance was worked out as per the formula given by Johnson *et al.* (1955).

RESULTS AND DISCUSSION

The analysis of variance for different

characters showed significant differences among genotypes as evident from the higher range for all the characters indicating variability of the material used for the study. All the genotypes recorded significant fruit yield over local check CBS-04-01 but local check recorded maximum plant height (Table 1). Among the genotypes HLB-25 recorded highest fruit yield of 464.7q/ha followed by KS 358 (378.0q/ha) and JBGL-01-01 (367.5 q/ha). The genotype HLB-25 recorded maximum number of branches per plant (8.33) followed by CBS-05-30 and CBS-05-08. The genotype DBL-24 showed maximum plant canopy (106.67 cm) followed by CBS-05-08 and CBS-05-14. Punjab sadabahar showed maximum fruit length (16.77 cm) while CBS-05-08 recorded maximum fruit width (5.33 cm) and KS-356 registered height fruit weight (71.60 g), respectively (Table 1). Maximum number of fruits per plant (26.00) was recorded in HLB-25, where records yield of 464.68q/ha was registered. This genotype was found statistically superior to rest of the genotypes with respect to above mentioned characters.

It is evident from Table 2 that maximum range was observed in fruit weight (30.77-71.60 g) followed by number of fruits (7.27-26.00), fruit yield (151.08-464.68 q/ha) and number of branches /plant (2.47-8.33). The GCV ranged from 9.44 and 12.01 in plant height to 30.90 and 32.32 in number of fruits/plant. A wide range of variability alongwith high estimates of GCV and PCV were recorded for number of fruit/ plant (30.90 and 32.32) fruit yield (29.26), fruit length (18.58 and 30.32), number of branches per plant (27.43 and 32.15), average fruit weight (20.21 and 21.46) and fruit width (19.42 and 23.24). However, moderate GCV and PCV were recorded for plant height (13.15 and 15.03) and plant canopy (9.44 and 12.02). The magnitude of PCV was greater than the corresponding GCV for all the characters denoting environmental factors influencing their expression. The findings are in conformity with Negi *et al.* (2000). Mohanty (2001) and Mahaveer *et al.* (2004) in brinjal.

The heritability values of more than 70 % was recorded for fruit yield, number of fruits/ plant, fruit length, fruit weight, plant height and no of branches/ plant, however moderate heritability values observed in plant canopy and fruit width. High level of heritability suggested that the environmental effects constitute a minor portion of total phenotypic variation and hence direct selection for these characters will be effective (Baswana *et al.* 2002).

Johnson *et al.* (1955) reported that high heritability along with high genetic gain was more efficient and dependable in predicting the improvement through selection. High values of heritability coupled with high genetic gain were observed for average fruit weight, number of fruits per plant, fruit yield, number of branches per plant, fruit width and fruit length which must be assigned to additive gene action, conditioning their expression and phenotypic selection for their amelioration could be brought about by simple methods. High to moderate estimates of heritability accompanied by moderate genetic gain were noticed for plant height and plant canopy which might be attributed to non-additive gene action regulating their importance and simple selection would be rewarding (Mohanty and Prusti, 2002).

It became clear from the above discussion that HLB-25 performs best with respect to number of fruits per plant with optimum fruit weight hence showing a yield of 464.68 q/ha. Other genotypes like KS-358 and JBGL-01-01 also perform better with a yield of 378.00 and 367.50q/ha respectively. High heritability coupled with high genetic gain values for yield and its attributing traits indicated genetic governance by additive gene action and hence these genotypes can be improved through simple selection procedure.

Table 1. Mean performance of brinjal genotypes for different characters

Genotype	Plant height (cm)	No. of branches/ plant	Plant canopy (cm)	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	No. of fruits/ plant	Yield (q/ha)
SMB-15	90.33	6.60	87.13	6.63	3.13	43.87	12.67	194.13
HLB-25	89.60	8.33	85.97	16.27	3.73	51.22	26.00	464.68
PB-67	96.20	4.40	84.77	13.47	3.23	50.80	20.13	356.18
SH-SB-101	119.93	2.47	87.80	13.50	3.77	59.17	14.20	286.88
KS-358	97.53	4.93	85.00	9.37	4.73	67.33	16.13	378.00
JBGL-01-01	114.87	5.01	84.33	9.27	3.03	67.73	15.53	367.50
KS-356	118.53	4.80	87.70	10.23	3.77	71.60	13.80	343.82
PB-64	104.67	4.27	88.77	10.67	3.67	6567	9.80	223.53
JBL-03-04	104.27	4.67	81.97	8.47	4.23	63.33	9.00	166.95
PB-66	78.93	3.20	82.20	12.90	2.57	53.00	10.60	195.65
CBS-04-01 (C)	135.67	6.40	85.87	11.23	3.43	60.10	7.27	151.08
KS-331 (C)	118.23	5.20	84.60	13.07	4.33	61.70	15.13	324.92
Pb. Sadabhar (C)	85.33	5.13	69.43	16.77	3.07	48.00	18.00	300.53
DBL-24	116.67	5.60	106	12.57	3.60	47.67	19.73	328.41
CBS-05-14	107.83	4.00	91.00	8.73	5.20	74.67	11.83	308.37
CBS-05-30	118.67	7.33	72.23	8.70	5.33	40.87	21.47	306.76
CBS-05-08	116.13	7.00	106.23	10.47	5.03	52.33	16.80	306.41
CBS-05-06	105.00	3.67	85.93	4.20	3.43	30.77	18.58	199.28
(CD at 5%)	12.85	1.44	10.67	1.83	0.81	6.65	2.41	17.28
CV	7.27	16.76	7.44	10.12	12.76	7.22	9.50	3.60

Table 2. Estimation of variability, heritability and genetic advance for different traits of brinjal genotypes

Character	Range	Mean	SEM±	Coefficient of variations		Heritability (%)	Genetic advance	Genetic gain (%)
				GCV	PCV			
Plant height (cm)	78.93-135.67	106.57	6.33	13.15	15.03	76.60	25.27	23.71
Number of branches/plant	2.47-8.33	5.17	0.71	27.43	32.15	72.80	2.49	48.16
Plant canopy (cm)	69.43-106.47	86.52	5.25	9.44	12.02	60.70	13.22	15.27
Fruit length (cm)	4.20-16.77	10.91	0.90	28.58	30.32	88.90	3.06	28.04
Fruit width (cm)	3.03-5.33	3.85	0.40	19.42	23.24	69.80	1.29	33.50
Average fruit weight (g)	30.77-71.60	35.54	3.27	20.21	21.46	88.70	31.77	61.12
Number of fruits/ plant	7.27-26.00	15.37	1.19	30.90	32.32	91.40	9.35	60.83
Fruit yield (q/ha)	151.08-464.68	289.06	8.51	29.04	29.26	98.50	171.60	59.36

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STUDIES ON GENETIC VARIABILITY FOR GROWTH, YIELD ATTRIBUTING TRAITS AND YIELD IN TOMATO (*LYCOPERSICON ESCULENTUM* MILL) GENOTYPES UNDER POLYHOUSE

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ABSTRACT

The experiment was conducted during summer season with 30 numbers of tomato germplasms under naturally ventilated polyhouse. Different growth and yield attributing characters like plant height, branch number, percentage of fruit setting, fruits per plant and yield per plant were determined. Highly significant variability was recorded in plant height, branch number, days to 50% flowering, days to 50% fruiting, fruits per plant and yield per plant respectively. The highest yield of 3233.33 g per plant was recorded in the genotype CLN 2366A. The highest numbers of fruit per plant was registered in the genotype CLN 2366A (66.33). GCV varies from 9.08 to 39.83%. There was closer relationship between PCV and GCV, which indicates less influence of environment for most of the characters. High value of heritability was observed in all the characters except branch number, which indicates the additive gene effects could be more important for these traits. Therefore improvement of these traits would be more effective by selection for further generation in the present materials.

Key words : Tomato genotypes, polyhouse, GCV, PCV, heritability, yield.

Tomato is commercially grown during winter season in Assam. During summer, when the temperature exceeds 29° C, the fruit set is impaired because of various causes like style elongation, lack of pollination, reduced pollen germination and slow pollen tube growth (Abdalla and Verkerk, 1968). Although number of hot-set tomato genotypes have been reported from different parts of the world. (Rana and Kalloo, 1989), however their performance are not evaluated under hot humid climate of Assam. For summer production therefore it is important to explore genetic potentiality for yield attributing and quality characters. Partitioning the variance into various components provides information regarding breeding value and nature and magnitude of variability in the expression of a particular trait. Correlation studies of yield with other characters will provide information regarding effect of selection for one character on the direction and magnitude of change in the others, which is important when simultaneous improvement, is needed. The present experiment was carried out to generate information in respect of some genetic parameters in relation to heat tolerance.

MATERIALS AND METHODS

The expeimenta material consisted of thirty tomato genotypes (Table 1). The genotypes were tested during summer season of 2004 at Experimental Farm, Department of Horticulture, Assam Agricultural University under plastic rain shelter condition. The experiment waw conducted in randomized block design with three replications compnsmg 10 plants for each genotype in each replication. The seedlings were transplanted by maintaining 60cm between rows and 45 cm between plants. Observations for the characters *viz.* Plant height (cm), branch number, days to 50 per cent flowering, days to 50 per cent fruit set, fruits per plant, yield per plant were determined as per standard procedures. Above parameters were recorded from 5 sampled plants in each replication for each genotypes. Variability existing in the different characters was estimated as suggested by Burton (1952). Heritability was estimated as per the formula suggested by Hanson *et al.*, (1956). The expected genetic

Table 1. Performance of tomato cultivars under plastic rain shelter

Variety	Plant height (cm)	Branch number	First flowering (days)	50% flowering (days)	First fruiting (days)	50% fruiting (days)	Fruits, plant	Average fruit weight (g)	Yield (g/ plant)
BL1173	124.67	5.67	44.67	67.33	57.33	75.67	27.00	66.30	1173.33
BL1176	110.00	6.00	35.67	55.33	46.00	59.00	20.33	55.06	926.67
BLI175	92.00	5.00	35.00	55.33	44.00	61.00	24.67	58.50	1460.00
CLN2026B	101.00	6.67	50.67	74.33	65.66	80.00	35.33	84.33	1760.00
CLN2001A	82.67	5.00	35.00	47.33	38.00	41.33	49.67	28.17	2413.33
CLN1621L	104.00	7.00	26.00	47.33	38.00	53.67	57.33	39.80	2316.67
CLN2443A	82.67	5.00	35.00	52.33	42.00	59.67	24.33	52.90	1650.00
CLN2366A	141.67	6.00	35.67	49.67	41.00	57.33	66.33	58.40	3233.33
BTI0	115.00	5.33	37.00	52.00	41.67	53.67	45.00	58.30	2250.00
VC 48-1	150.00	6.33	33.67	50.67	45.33	61.33	40.67	46.80	1511.33
NS7531	91.53	7.93	30.00	37.00	36.33	40.67	27.40	58.10	922.67
NS1945	89.07	8.53	27.33	33.67	34.67	40.33	24.53	58.50	851.67
NS2145	92.80	9.20	32.00	35.00	32.00	42.00	28.00	39.73	1008.33
DRD8014	125.47	10.53	31.67	33.33	38.00	40.67	26.07	45.70	1093.33
Hyb-Sc-3	97.90	8.00	28.33	33.00	36.00	40.67	21.73	42.53	1283.67
Hyb-621	115.40	9.33	31.67	34.67	39.00	42.67	24.27	77.40	1157.33
NTH2004	119.80	10.33	26.33	33.67	35.33	40.00	23.00	67.53	1309.67
Yash	152.40	14.07	27.33	30.67	33.00	37.0	31.47	86.03	1757.67
CTH-230	143.53	7.53	29.67	32.00	34.00	38.67	19.13	67.53	629.00
P. Hyb-1	109.80	8.80	30.00	32.67	38.33	40.33	27.33	43.13	1173.00
A. Shreshta	112.27	7.80	32.00	34.67	41.00	48.00	18.27	50.73	949.33
A. Abhijit	116.27	7.87	29.67	36.00	40.00	43.00	19.13	48.53	903.00
A. Vikas	109.73	9.33	27.00	32.67	35.67	41.67	23.47	45.77	996.00
A. Saurabh	104.73	10.07	27.00	29.67	33.33	39.00	24.67	74.77	1001.67
A. Ahuti	103.67	11.53	29.67	33.33	37.00	42.33	30.87	47.83	1397.67
A. Ashish	78.47	12.67	25.33	29.00	32.00	39.33	27.73	68.13	1569.33
A. Meghali	115.27	9.40	27.67	28.67	34.67	42.33	28.33	56.9	1414.67
A. Alok	99.80	10.80	28.67	32.33	34.33	40.33	22.60	79.2	1174.67
Sioux	139.67	12.13	27.67	35.67	33.33	41.33	19.40	69.37	813.67
BTI	88.40	11.00	25.33	28.00	33.00	43.33	29.53	26.83	795.33
CD at 5%	18.05	2.11	3.22	3.21	1.74	3.15	10.05	16.51	500.714

advance of the available germplasm at 5% intensity of selection was calculated as per Johnson et al., (1955)

RESULT AND DISCUSSIONS

Highly significant variability was recorded in plant height (78.47 - 152.40cm), branch number (5.00 - 14.07), days to 50% flowering (28.00-74.33), days to 50% fruit set (37.00-80.00), number of fruits per plant (18.27-66.33) and yield per plant (629.00 - 3235.38 g). The highest yield of3.23kg per plant was registered in tomato genotype CLN 2366A followed by CLN 2001A with a yield of 2.41 kg per plant. More number of fruit per plant was recorded in the genotype CLN 2366A (66.33) and followed by CLN 200IA (49.67) and were responsible for high yield for both the genotypes. The characters showing high range of variation indicate little scope for improvement.

Table 2. Estimates of variance components and related genetic parameters for yield and other components in tomato

Characters	Mean	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic advance (%)
Plant height (cm)	109.92	70.00	18.19	20.78	76.34	32.96
Branch number	8.53	5.00	9.08	17.70	26.43	9.49
Days to 50% flowering	39.66	28.00	17.20	17.89	92.32	33.94
Days to 50% fruiting	47.54	37.00	23.89	24.23	97.21	48.42
No. of fruits/plant	29.59	19.13	36.86	42.32	75.87	65.39
Yield (g/plant)	1363.21	629.00	39.83	45.73	75.85	70.65

Estimates of nature and magnitude of genetic variability and heritability are useful in providing basic information regarding genetic architecture of the germplasm, production and formulation of appropriate breeding procedures, which will boost up crop improvement programme.

The estimate of variance compounds and related genetic parameters for different characters in tomato genotypes are presented in Table 2. GCV, which gives a picture of extent of genetic variability in the population ranged from 9.08 per cent (number of branch) to 39.83 per cent (yield/plant). GCV values were considerably high for the characters yield per plant, number of fruit per plant. There characters having high range of variation have a better scope for improvement through selection. Data presented in the Table 2, shows that there was closer relationship between PCV and GCV and there were less difference between them except the characters branch number, indicating less influence of environment for most of the characters.

The efficiency of selection for a particular character is best reflected by the extent of heritability for the character. Heritability estimates gives useful information for the relative values of selection based on phenotypic expression of the quantitative traits. In the present study, the heritability estimates were high in days to 50 per cent fruits, days to 50 per cent flowering, moderately high in plant height, number of fruit per plant and yield per plant which indicated that selection based on phenotypic performance might be effective for these characters. Similar observations were also reported by Khurana et al., (2003) and Dhankhar and Dhankhar (2002). Low value of heritability was observed in branch number indicates the presence of high degree of environmental influence upon the characters. Therefore direct selection for this character will be low effective.

The information on heritability in combination with genetic advance gives the reliability of selection procedure. In the present study high genetic advance coupled with high heritability was observed for all the characters except branch number. It indicated that the additive gene effects could be more important for these traits. Therefore, improvement in these traits would be more effective by selection for further generation in the present material. These results are in consonance with Ponda and Singh (1997). On the contrary branch number was found to be a character with least genetic variation and thus not suitable to include it as a selection criteria. Similar request was also put forwarded by Phookan *et al.,* (1998).

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EVALUATION OF FRONT LINE DEMONSTRATIONS ON BLACKGRAM IN IRRIGATED AGROECOSYSTEM

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ABSTRACT

Front line demonstrations on blackgram were conducted at farmers' fields in district Kurukshetra (Haryana) during summer and *zaid* seasons of the years 2001-2004. Blackgram variety T-9 was grown in the nitch available after wheat/potato before rice during summer and after sorghum before wheat during *zaid* season to get additional returns. About 14 per cent higher grain yield was recorded under demonstrations than the farmers traditional practice and about 85 percent more grain yield was obtained during zaid season than summer season. The extension gap, technology gap and technology index were found *a.i.* 82 kg, 597 kg per ha and 47.6, respectively on overall average basis reflecting inadequate location specific improved, technology and insufficient extension net work to harvest the potentials. An additional investments of Rs. 626 per ha coupled with scientific monitoring of demonstrations and non-monetary factors resulted in additional return Rs. 1584 per ha. Fluctuating sale price of grains during different years influenced the economic returns per unit area. Incremental benefit: cost ratio of *zaid* blackgram (3.0) was higher than the summer blackgram (2.2) as a result of higher grain yield during *zaid* season.

Key words : Blackgram, demonstration, gap analysis, economics, grain yield, seasons.

Blackgram commonly known as urdbean is an important pulse crop grown in India. The production of pulses in India was 13.1 million tons against the requirement of 20 million tons (Gupta *et al.*, 2004) indicating the shortfall which is to be minimized either by increasing the area under pulses or by increasing the productivity of pulses. Most of the pulse crops are grown in rainfed, less fertile and discarded soils, and there is less area under pulses in northern part of country particularly where rice-wheat cropping sequence is dominating. Though the scope of shift in area from staple food cereals like rice and wheat seems to be negligible, yet the inclusion of short duration pulse crops like green gram and blackgram is quite feasible without affecting the major cropping sequences in irrigated agro-ecosystem. Such practice of growing pulse crops in between the major crops not only adds to the pulse production but also improves the declining fertility of soil. This will help enhance the production of pulses to meet the shortfall, and the aftermath effort of cereal based cropping systems in soil health, declining factor productivity, and term sustainability of farming system in irrigated agroecosystem. Blackgram being a short duration crop (70-80 days) can be grown in the nitch available after wheat before rice during summer, and during *zaid* after sorghum and early rice before sowing of wheat crop.

MATERIALS AND METHODS

Front line demonstrations on blackgram were conducted at farmers fields in district Kurukshetra (Haryana) to assess its performance during summer and *zaid* seasons as some fields remain vacant for about 70-75 days during these seasons. During summer season 25 demonstrations of one acre each in rice-wheat/potato cropping sequence after wheat were conducted during the years 2001, 2002 and 2004 and 10 demonstrations of one acre each were conducted in wheat-sorghum cropping sequence during the years 2002 and 2004. The soils of the district is generally low in nitrogen, low to medium in phosphorus and medium to high in potash. All the demonstrations were organized using recommended package of practices and the farmers were provided quality seed of blackgram variety T-9 during all the years of study. The sowing was done during last week of March to second fortnight of April in summer season, and during second fortnight of August in *zaid* season. The crop matured in 70 to 75 days with 2-3 days deviation during both the seasons (summer as well as *zaid*). The demonstrations were regularly monitored right from sowing to harvest by the scientists of Krishi Vigyan Kendra, Kurukshetra. The grain yield was recorded for demonstrations vis-a-vis farmers traditional practice. The data were analysed using averages as weighted means for both the seasons separately. Different parameters of gap analysis, costs and returns were calculated using the way suggested by Yadav *et al.* (2004) given as : i). Extension Gap = Demonstration yield (Di)-Farmers' practice (Pi); ii) Technology Gap = Potential yield (Pi)-Demonstration yield (Di); iii) Technology index = (Pi-Di)x100 / Pi; iv) Additional return = (Di-Fix) x Sale Price; v) Effective gain = Additional returns - additional cost; vi) Incremental benefit: cost ratio = Additional returns / Additional cost of cash inputs.

RESULTS AND DISCUSSION

Grain yield

There was 9 to 21.4 per cent more grain yield under demonstrations than farmers practice irrespective of the growing seasons. On an average 14.4.per cent yield advantage was recorded under demonstrations carried out with improved cultivation technology as compared to farmers traditional way of crop cultivation. The data in Table I clearly revealed that blackgram performed better during *zaid* season than the summer season irrespective study years and about 85 per cent more grain yield was recorded under summer than *zaid* sowing. The higher productivity during *zaid* season could be due to congenial environmental conditions during productive phase as compared to summer season influenced by very high temperature.

Gap Analysis

An extension gap of 40-150 kg per hectare was found between demonstrated technology and farmers practices during different years and on average basis the extension gap was 82 kg per ha (Table 1). The extension gap during summer season was less than the *zaid* season. Such gap might be attributed to adoption of improved technology in demonstrations which resulted in higher grain yield than the traditional practice. Wide technology gaps were observed during different years and even different seasons. On average basis the technology gap for summer season was 724 kg per ha which was much more than the *zaid* season (280 kg/ha) and on overall weighted average basis the technology gap of 35 demonstrations was found as 597 kg per ha. The difference in technology gap between two seasons could be due to more feasibility of recommended technology during *zaid* season comparison to summer season. Similarly, the technology indices for all the demonstrations were in accordance with technology gap. Higher technology index reflected the inadequate proven technology for transferring to farmers and insufficient extension services for transfer of technology.

Economic Analysis

The variables like seed, fertilizer and pesticides were considered as cash inputs for the demonstrations as well farmers' practice and an additional investment of Rs. 560 to 788 per ha was made under demonstrations costing cash inputs. Economic returns as a function of grain yield and sale price varied during different years. More returns during the year 2001 and 2004 were obtained due to higher sale price and higher grain yield, respectively. On average basis the returns per unit area were more during *zaid* season than summer season under demonstrations as well as farmers' traditional practice. Similarly, the higher additional returns and effective gain obtained under demonstrations could be due to improved technology, non-monetary factors, timely operations of crop cultivation and scientific monitoring. The

Table 1. Grain yield and gap analysis of front line demonstrations on blackgram at farmers' field

Year (Season)	No. of demonst rations	Variety	Potential yield (kg/ha)	Demon-stration yield (kg/ha)	Farmers' practice (kg/ha)	Increase over farmers' practice (%)	Extension gap (kg/ha)	Technology gap (kg/ha)	Technology index (%)
2001 (S)	10	T-9	1250	480	420	14.3	60	770	61.6
2002 (S)	10	T-9	1250	460	420	9.5	40	790	63.2
2002 (Z)	5	T-9	1250	850	700	21.4	150	400	32.0
2004 (S)	5	T-9	1250	750	620	21.0	130	500	40.0
2004 (Z)	5	T-9	1250	1090	1000	9.0	90	160	12.8
Average (S)	25	-	1250	526	460	14.3	66	724	57.9
Average (Z)	10	-	1250	970	850	14.1	120	280	22.4
Overall Average	35	-	1250	653	571	14.4	82	597	47.6

S-sum, Z- *zaid*

Table 2. Economic analysis of front line demonstrations on blakgram at farmers' field

Year (Season)	Cost of cash inputs (Rs/ha)		Additional cost in demon-stration (Rs/ha)	Sale price of grain (Rs/100 kg)	Total returns (Rs/ha)		Additional return in demon-stration (Rs/ha)	Effective gain (Rs/ha)	Incremental Benefit cost ratio (IBCR)
	Demon-stration	Farmers' practice			Demon-stration	Farmers' practice			
2001(S)	1925	1375	550	2600	12480	10920	1650	1010	1.8
2002(S)	2025	1555	470	2000	9200	8400	800	330	1.7
2002(Z)	2287	1537	750	1150	9775	8050	1725	975	2.3
2004(S)	2337	1575	762	1200	9000	7440	1560	798	2.0
2004(Z)	2412	1587	825	1200	13080	10000	3080	2255	3.7
Average(S)	2047	1487	560	2080	10941	9568	1256	696	2.2
Average(Z)	2350	1562	788	1175	11398	9987	2402	1614	3.0
Overall Average	2134	1508	626	1821	11891	10398	1584	958	2.5

incremental benefit: cost ratio (IBCR) ranged from 1.7 to 3.7 during different years (Table 2). Enhanced IBCR (3.0) during *zaid* season was due to higher grain yield resulting in more additional returns compared to summer season (2.2) and overall IBCR was found as 2.5.

The results confirm the findings of front line demonstrations on oilseeds and pulse crops by Singh *et al.* (2000), Singh *et al.* (2002) and Yadav *et al.* (2004).

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ASSOCIATION ANALYSIS IN PEACH (*PRUNUS PERSICA* L.) GENOTYPES FOR YIELD AND ITS CONTRIBUTING TRAITS

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ABSTRACT

Eleven genotypes of low chilling peach (*Prunus persica* L.) were studied for their, correlation and path coefficient analysis for yield and its thirteen contributing traits. Yield of peach genotypes had significant positive correlaion with number of fruit set, fruit weight, fruit length, fruit diameter, height, spread and chlorosis. Fruit weight had highly positive correlation with fruit length fruit diameter and stone weight, while fruit length with fruit diameter and stone weight. The path coefficient analysis indicated that fruit weight had the highest direct and positive effect followed by chlorosis, number of flowers per shoot, stone weight and number of shoots on yield per tree.

Key words : Peach, correlation, path coefficient, yield, chlorosis.

Peach (*Prunus persica* L.) is an important stone fruit grown in warm temperate zones of world. Nectarines are smooth-skin mutants closely related to peach. It is favourite table fruit and is highly valued for its taste and attractive colour. The fruits are rich source of sugars, vitamins and minerals and malic acid (1.2%). Prunacin is the principal glycoside present in the pulp while the glycoside, amygdalin is present in the seeds of peach (Voldrick and Kyzlink, 1990). It is successfully cultivated in Uttrakhand, Himachal Pradesh, Kashmir, parts of U.P., Punjab, Haryana and Assam. Low chilling cultivars are grown successfully under sub-mountainous regions of Uttrakhand (Krishna *et al.*, 2004). The low chilling cultivars are important for cultivation in view of rising temperature due to global warming, under transition zones of temperate region. This study covered different yield and its contributing traits with chlorosis and aphid infestation. In India, an unsystematic introduction and indiscriminate multiplication from various sources and types of base material in peach have resulted in a lot of variation in the existing population. Knowledge of association between yield and yield contributing characters of crop is of paramount importance in selection and hybridization programme. The present study was, therefore, undertaken to know the causal components of relationship among various traits by using correlation and path coefficient analysis. Such an analysis would be of immense practical utility in deciding the selection priorities. Keeping this in view, the present investigation was undertaken to know the association between yield and other traits and among themselves.

MATERIALS AND METHODS

Eleven peach accessions including two nectarines were studied for thirteen morphological traits as listed in Table 1. The selected genotypes planted in RBD with three representative plants of eighteen years age, planted at 6mx6m spacing having uniform training and pruning and grafted on Kabul greengage rootstock,contributed as experimental plant material. Genotypes of peach fruit were introduced from different parts of world. The morphological traits such as yield (kg/tree), number of shoots, number of flowers/shoot, number of fruit set, fruit weight (g), fruit length (cm), fruit diameter (cm), stone weight (g), tree height (m), tree spread (m), stem girth (cm), chlorosis (%) and aphid infestation (%) were observed by using standard methods. Phenotypic and genotypic correlations were calculated as per the method given by Fisher (1954). Path coefficient analysis based on genotypic correlations was performed according to Dewey and Lu (1959).

Table 1. Phenotypic correlation coefficient among various traits in peach genotypes

Traits	No. of shoots	No. of flowers	No. of fruit set / shoot	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Stone weight (g)	Height (m)	Spread (m)	Stem girth (em)	Chlorosis (%)	Aphid infestation (%)
Yield (kg/tree)	0.255	0.300	0.593*	0.606*	0.631*	0.598*	0.627*	0.559*	0.583*	0.335	0.709*	-0.112
No. of shoots		-0.087	-0.015	0.086	0.144	0.075	0.536*	-0.252	-0.192	-0.296	-0.124	0.156
No. of flowers / shoot			0.158	0.305	0.402*	0.440*	0.268	0.312	0.530*	0.513*	0.086	0.047
No. of fruit set				0.547*	0.546*	0.597*	0.312	0.567*	0.509*	0.548*	0.614*	-0.657
Fruit weight (g)					0.960**	0.976**	0.806**	0.229	0.246	0.088	0.232	-0.243
Fruit length(cm)						0.952**	0.890**	0.189	0.212	0.047	0.136	-0.222
Fruit diameter (cm)							0.793**	0.273	0.305	0.190	0.239	-0.272
Stone weight (g)								-0.034	0.Q18	-0.247	-0.035	-0.112
Height (m)									0.936**	0.837**	0.719	0.142
Spread (m										0.807**	0.652	0.107
Stem girth (cm)											0.710	0.156
Chlorosis (%)												-0.063
Aphid infestation (%)												

** Significant at 0.01 level

* Singificant at 0.05 level

Results and Discussion

The correlation coefficients estimated in all the possible ways among the different traits are presented in Table 1. The values of genotypic correlation coefficient were higher than phenotypic correlation coefficient for all the traits. Yield had positive and significant correlation with number of fruit set (0.593), fruit weight (0.606), fruit length (0.631), fruit diameter (0.598), stone weight (0.627), height (0.559), spread (0.583) and chlorosis (0.709). This indicated that improvement in yield can also be achieved through improvement in these traits. The number of shoots showed positive correlation with stone weight (0.536). The number of flowers/shoot had positive relation with fruit length (0.402), fruit diameter (0.440), spread (0.530) and stem girth (0.513), while number of fruit set had positive corelation with fruit weight (0.547), fruit length (0.546), fruit diameter (0.597), height (0.567), spread (0.509), stem girth (0.548) and chlorosis (0.614). The height, spread and stem girth of trees also had positive corelation with leaf chlorosis (0.719, 0.652 and 0.710, respectively). Fruit weight had highly positive correlation with fruit length (0.960), fruit diameter (0.976) and stone weight (0.806), while fruit length with fruit diameter (0.952) and stone weight (0.890). Fruit diameter has highly positive correlation with stone weight (0.793). The height of peach tree was highly positive correlated with spread (0.936) and stem girth (0.837), while tree spread with stem girth (0.807). Significant correlations of yield contributing traits suggested the scope of direct and indirect effective selections for further improvement. These findings were also supported by Saran *et al.* (2007) in Indian jujube and Sofi *et al.* (2001) in apricot.

In present investigation path coefficient analysis was done on the basis of genotypic correlation and the results are presented in Table 2. The critical evaluation of path coefficient analysis indicated that fruit weight had the highest direct and positive effect (1.453) on yield per tree followed by chlorosis (0.865), number of flowers / shoot (0.859), stone weight (0.681) and number of shoots (0.214). The highest direct negative effect was recorded for aphid infestation (-0.433). Regarding indirect effects, it was observed that stone weight (0.548) and number of flowers/ shoot (0.262) were indirectly contributing via

Table 2. Direct (diagonal) and indirect effect of component characters on yield of peach genotypes

Traits	No. of shoots	No. of flowers	No. of fruit / shoot	Fruit weight (g)	Stone weight (g)	Chlorosis (%)	Aphid infestation (%)
No. of shoots	**0.214**	-0.019	-0.003	0.018	0.115	-0.026	0.033
No. of flowers /shoot	-0.075	**0.859**	0.136	0.262	0.230	0.074	-0.040
No. of fruit set	0.004	-0.046	**-0.293**	-0.160	-0.092	-0.180	0.192
Fruit weight (g)	0.126	0.443	0.794	**1.453**	1.171	0.337	-0.353
Stone weight (g)	0.365	0.182	0.213	0.548	**0.681**	-0.024	-0.076
Chlorosis (%)	-0.107	0.075	0.531	0.201	-0.030	**0.865**	-0.055
Aphid infestation (%)	-0.068	-0.020	0.285	0.105	0.048	0.027	**-0.433**

Bold diagonal values are direct effects
Residual value= 0.521

fruit weight. Fruit weight contributed to the yield mainly through its direct effect (1.453) followed by indirect effect of stone weight (1.171) and number of fruit set (0.794). The overall picture showed that significant positive correlation of these traits with fruit yield were due to fruit weight. Similar reports are available from Sofi *et al.* (2001) in apricot and Saran *et al.* (2007) in ber who observed that the significant positive correlation of these traits with fruit yield was due to fruit weight.

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EFFECT OF PLANT DENSITIES AND FERTILIZER LEVELS ON GROWTH AND NPZN UPTAKE BY EXTRA EARLY SORGHUM (*SORGHUM BICOLOR* L. MONECH) GENOTYPE

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ABSTRACT

A field experiment in split plot design with three replications was conducted during *kharif* 2003 and 2004 to study the effect of plant densities and fertilizer levels on growth and NPZn uptake by an extra early sorghum genotype (SPV-1489). Significant increases in plant height, dry matter accumulation/plant and number of green leaves under plant density at 2.90 lac plants/ha were observed as compared to plant density at 1.50 lac plants/ha. Plant population with increasing densities from 1.50 to 2.90 lac plants/ha gave significant increase in leaf area index and specific leaf weight. Plant density at 2.20 lac plants ha^{-1} gace significantly higher grain yield over plant density at 1.50 lac plants/ha which was higher by 9.24 q/ha. Plant density at 2.20 lac plants/ha gave significant increase in nitrogen and phosphorus uptake as well as zinc uptake by grain and stover. Application of 80 kg N + 40 kg P_2O_5/ha produced significantly higher plant height and dry matter accumulation, leaf area index, number of green leaves and grain yield as well as NPZn uptake by grain and stover application of 60 kg N + 30 kg P_2O_5/ha. Application of 100 kg N + kg P_2O_5/ha and 80 kg N + 40 kg P_2O_5/ha levels gave increases in grain yield by 20.4 and 18.7 per cent, respectively over application of 60 kg N + 30 kg P_2O_5/ha. Further, maximum specific leaf weight was obtained under application of 60 kg N + 30 kg P_2O_5/ha. Application of zinc sulphate @ 25 kg/ha significantly increased dry matter accumulation, leaf area index and number of leaves, grain yield and zinc uptake by grain and stover as compared to control.

Key words : Fertilizer levels, growth characteristics, nutrient uptake and yield, plant densities, sorghum

Among cereals, sorghum is the third most important crop after rice and wheat in India. To large extent, farmers apply nitrogen only through urea or apply N and P through DAP, but in much less quantity than the actual withdrawal or needed. The gap between the nutrient removal and supply cannot be bridged-up with the application of any single nutrient alone, but this has to be bridged-up with the balanced use of fertilizers. Since optimum fertilizer dose is dependent on several factors like soil, genotype, environment, growing situations etc, so it is quite reasonable to work out economically viable fertilizer dose for the extra early type (SVP-1489) which matures in 80-85 days. It is probable that this genotype is grown at higher density, it may require higher doses of fertilizers than that is recommended. Likewise, it may need lower fertilizer dose when cultivated at normal recommended plant density. The role of zinc in crop nutrition is well recognized as it is used for bio synthesis of plant auxins, nitrogen metabolism, oxidation-reduction reactions, which is considered to be necessary for plant growth and development (Tisdale, *et al.*, 2002). Adequate plant stand and optimum plant nutrition have the profound bearing on growth, yield and nutrient uptake of sorghum.

MATERIALS AND METHODS

The field experiment was conducted at the Instructional Farm (Agronomy), Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan) during *kharif*, 2003 and 2004. The soil of experimental site was clay loam in texture and alkaline in reaction (pH 7.8). It was medium in available nitrogen (274.80 kg/ha), medium in available phosphorous (18.75 kg/ha), medium available in potassium (207.00 kg/ha), and low in available zinc (0.51 ppm). The experiment was laid out in split plot design with three replications. The treatments comprised combinations of three plant densities (1.50 lac plants, 2.20 lac plants lac plants and 2.90 lac plants/ha) and three fertilizer levels (60:30, 80:40 and 100:50 kg N:kg P_2O_5/ha) allocated in the main plots and two zinc sulphate levels (control and 25 kg $ZnSO_4$/ha) in the sub-plots, thereby making eighteen treatment combinations. Nitrogen was applied in two equal splits-half at sowing and the rest half at 35 days after sowing when there was adequate moisture in the soil. A uniform dose of phosphorus was applied as basal. These nutrients were applied through urea and DAP. Zinc was applied through zinc sulphate @ 25 kg ha^{-1} as basal at the time of sowing by drilling in furrows at 5 cm below the seeding depth.

RESULTS AND DISCUSSION

Growth characters

Plant density at 1.50 lac plant/ha gave the lowest plant height (Table 1). Significantly increases in plant height with increasing population densities from 1.50 to 2.90 lac plants/ha seem to be the resultant of mutual shading due to over crowding of plants. Mutual shading due to increased population might have reduced the availability of light within the crop canopy and accelerated the elongation at lower internodes, resulting into increased plant height. Increasing plant densities from 1.50 to 2.90 lac plants/ha decreased dry matter accumulation. Whereas, the crop raised under higher density of 2.90 lac plants/ha attained the highest leaf area index, leaf specific weight and number of green leaf, which were significantly higher over lower densities of 1.50 and 2.20 lac plants/ha (Table 1). The observed inverse relationship between high plant density and dry matter accumulation seems to be on account of increased competitive interaction among the plants for need of various growth inputs from below and above ground i.e., nutrients and solar radiation. Unfavorable nutritional environment with each increment in population density seems to have adversely affected various metabolic activities in the plant systems, which are indispensable for growth characters like dry matter production. The results are in close agreement with the findings of Balasubraman and Ramamoorty (1996).

Increasing rate of fertilizer application upto 80 kg N + 40 kg P_2O_5/ha significantly improved plant growth characters *viz.*, plant height, dry matter accumulation, number of green leaves per plant, leaf area index and specific leaf weight as compared to 60 kg N + 30 kg P_2O_5/ha (Table 1). The profound influence of balanced and increased fertilization comprising combinations of nitrogen and phosphorus on the crop growth seems to be due to maintaining congenial nutritional environment of plant system on account of their greater availability from the soil media. This is well evinced from estimates of higher uptake of nutrients at successive growth stages and at harvest, which showed that application of nitrogen and phosphorus improved plant growth. The extensive root system helps in exploiting the maximum nutrients and water from the soil (Tandon, 1987).

Application of zinc sulphate @ 25 kg/ha gave significantly higher dry matter accumulation, leaf area index and number of green leaf/plant (Table 1). It has been documented that Zn plays important role in synthesis of various enzymes like carbonic anhydrate, glutamic acid dehydrogenase, lactic acid dehydrogenase and some peptidases. It is also considered to be a precursor for auxin synthesis, involved in nitrogen metabolism and several oxidation reduction reactions, stability of RNA and starch formation. Thus, its adequate supply results in higher dry matter production, ultimately growth and development of plants (Maiti, 1996).

Yield

Plant density at 2.20 lac plants/ha gave significantly higher grain and stover yield as well as biological yield over plant density at 1.50 plants/ha but was found at par with plant density at 2.90 lac plants/ha. Plant density at 2.20 lac plants/ha recorded higher grain yield by 9.24

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Table 1. Effect of plant densities, fertilizer levels and zinc sulphate levels on plant height at harvest, dry matter accumulation, leaf area index, specific leaf weight, number of green leaves and grain yield (pooled data of 2 years)

Treatment	Plant height at harvest (cm)	Dry matter accumulation (g/plant)	Leaf area index	Specific leaf weight (cm^2/g)	No. of green leaves /plant	Grain yield (q/ha)
Plant densities (lakh/ha)						
1.50	139.49	61.01	1.90	284.35	8.68	41.10
2.20	148.71	56.83	2.91	327.30	9.05	50.34
2.90	151.78	52.92	3.91	365.84	9.22	46.15
CD (P=0.05)	6.21	2.61	0.093	9.46	0.33	2.14
Fertilizer levels (N:P_2O_5 kg/ha)						
60:30	137.75	51.18	2.76	343.82	8.59	40.57
80:40	149.74	59.10	2.96	316.19	9.11	48.15
100:50	152.50	60.48	3.00	317.48	9.24	48.87
CD (P=0.05)	6.21	2.61	0.093	9.46	0.33	2.14
Zinc Sulphate levels (kg/ha)						
Control	145.51	53.89	2.79	331.63	8.72	42.90
25	147.81	59.95	3.02	32.02	9.24	48.82
CD (P=0.05)	NS	1.89	0.057	NS	0.23	1.65

Table 2. **Effect of plant densities, fertilizer levels and zinc sulphate levels on NPZN uptake by crop (pooled data of 2 years)**

Treatment	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Zinc uptake (g/ha)	
	Grain	Stover	Grain	Stover	Grain	Stover
Plant densities (lakh/ha)						
1.50	71.79	25.00	12.06	9.48	233.45	144.63
2.20	86.99	29.76	14.71	11.20	281.23	169.91
2.90	79.08	27.14	13.39	10.22	253.66	155.75
CD (P=0.05)	6.21	2.61	0.093	9.46	0.33	2.14
Fertilizer levels (N:P_2O_5 kg/ha)						
60:30	67.21	23.52	11.35	9.03	224.62	140.68
80:40	84.07	28.76	14.14	10.73	268.78	163.48
100:50	152.50	60.48	3.00	317.48	9.24	48.87
CD (P=0.05)	4.16	2.33	0.62	0.75	13.86	11.41
Zinc Sulphate levels (kg/ha)						
Control	73.53	25.88	12.79	9.75	226.21	141.32
25	85.04	28.72	14.29	10.86	286.01	172.21
CD (P=0.05)	2.81	1.02	0.50	0.42	11.10	5.12

and 4.19 q/ha over plant densities at 1.50 and 2.90 lac plants/ha, respectively (Table 1). Despite of inverse relationship between various yield components and plant densities, significant increase in crop productivity upto the plant density level of 2.20 lac plants/ha could be ascribed to increase in number of plants per unit area. This is very well reflected from the increased biological yield (grain + stover yield) which implies that the above ground environment (solar radiation and CO_2) was efficiently utilized. The results are in conformity with the findings of Ameta (1993).

Application of 80 kg N + 40 kg P_2O_5/ha produced significantly higher grain yield, stover yield and biological yield as compared to application of 60 kg N + 30 kg P_2O_5/ha, but the former level was found at par with 100 kg N + 50 kg P_2O_5/ha level. Application of 100 kg N + 50 kg P_2O_5/ha and 80 kg N + 40 kg P_2O_5/ha gave increases in grain yield by 20.4 and 18.7 per cent, respectively over application of 60 kg N + 30 kg P_2O_5/ha. The higher biomass yield under the influence of 80 kg N + 40 kg P_2O_5/ha could be ascribed to its positive influence on both vegetative and reproductive growth of the crop which led to increase in yield attributes, grain and stover yield, thereby higher biomass (biological yield) production/ha. The results of present investigation corroborate findings of Singh and Sumaria (2002).

The results showed that application of zinc sulphate @ 25 kg/ha produced significant increases in grain, stover and biological yields as compared to control (Table 2). The existence of favorable nutritional environment below ground and above ground (plant parts) under the influence of zinc nutritional had a positiveinfluence on both the phases of crop, which ultimately led to realization of higher yields. The findings are in close agreement with findings of Gaur *et al.* (1991)

Nutrient uptake

Nitrogen, phosphorus and zinc uptake by grain and stover was significantly highest under plant density at 2.20 lac plants/ha (Table 2). These significant increases in uptake of nutrients with increasing plant density upto 2.20 lac plants/ha could be attributed entirely due to increased biomass. The concomitant improvements in these components under plant density of 2.20 lac plants/ha ultimately reflected in higher accumulation of nutrients. The findings are in close agreements with the findings of Singh and Srivastava (1997).

The nitrogen and phosphorus uptake by grain and stover also tended to increase with application of increasing level of fertilizers upto 80 kg N + 40 kg P_2O_5/ha over its lower level of 60 kg N + 30 kg P_2O_5/ha but was found at par with application of 100 kg N + 40 kg P_2O_5/ha (Table 2). This might have promoted growth of roots as well as functional activity resulting in higher extraction of nutrients from soil environment to aerial plant parts. The results of the present investigation strongly support findings of Jain (2001).

Application of zinc sulphate @ 25 kg/ha significantly enhanced zinc content and uptake by grain and stover as compared to control (Table 2). Improvement in nutrient status with basal zinc application seems to be on account of higher dry matter accumulation as well nutrient status. The results of present investigation indicating positive response of zinc sulphate corroborate findings of Krishnasamy (1996).

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EFFECT OF SOWING TIME ON PERFORMANCE OF SOYBEAN *[GLYCINE MAX* (L.) MERILL] VARIETIES DURING *RABI* AND *SUMMER*

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Abstract

Field experiment was conducted during *rabi* and summer reasons of 2004 and 2005 on vertisols at Adilabad, Andhra Pradesh, to study the performance of soybean varieties JS-335, PK-1029 and MACS-450 with different sowing dates. Soybean mean seed yield was higher in *rabi* season than summer season. September 20th sowing of 'JS-335' variety was promising in *rabi* while in summer, sowing on January 30th with JS-335 variety performed better.

Key words : Soybean, seed yield, varieties.

Soybean is becoming increasingly popular among farmers because of assured yield and remunerative prices due to its high oil (20%) and protein (43%) contents. It can aptly be called as "miracle crop" of 20th century. It has greater potentiality to substitute different oilseeds and pulses to overcome the shortage of edible oil and protein rich food. This crop is mainly grown during *kharif* season in vertisols of Andhra Pradesh. There is great scope for extending its cultivation to *rabi* and summer seasons. Sowing time of any crop usually determines the seed potential of any variety. Hence, the present investigation was carried out to study the performance of soybean during rabi and in summer with different varieties and time of sowing.

Materials and Methods

A field trial was conducted at Agricultural Research Station, Adilabad, Andhra Pradesh, India during *rabi* 2004-05 and 2005-06 and in summer 2004 and 2005. The soil of the experimental site was low in available nitrogen (135 kg ha^{-1}), low in available phosphorus (21 kg ha^{-1}) and high in potassium (215 kg ha^{-1}) with a soil pH of 8.2 and electrical conductivity of 0.35 ds/m. The trial was laid out in split plot design with 3 replications. Treatments included five dates of sowing in *rabi* (20th and 30th September, 10th, 20th and 30th October) and four dates in summer (20th and 30th January, 9th and 19th February) as main plots and 3 varieties (JS-335, PK-1029 and MACS-450) in sub-plots both in *rabi* and summer. 30:60:40 kg NPK ha^{-1} was applied entirely as basal in both seasons and crop was sown at 30 x 10 cm. A rainfall of 160.4 mm (6 rainy days) and 157.2 mm (8 rainy days) was received during 2004 and 2005 *rabi* during crop growth. In summer 2004 and 2005 a rainfall of 57.7 mm (6 rainy days) and 187.4 mm (8 rainy days) was received during the crop growth period. The monthly mean maximum and minimum temperatures during *rabi* 2004 were 30.8°C and 16.8°C while in 2005 *rabi* they were 30.4°C and 15.5°C. Similarly in summer 2004, mean monthly maximum and minimum temperatures were 36.7°C and 21.4°C and in summer 2005, they were 36.3°C and 21.0°C.

Results and Discussion

Effect of varieties

Three varieties 'JS-335', 'PK-1029' and 'MACS-450' significantly differed in number of pods per plant and seed yield both in *rabi* and summer seasons. Mean seed yield of different varieties was almost uniform during *rabi* (919 kg ha^{-1}) and in summer (904 kg ha^{-1}) (Table 1b and 2b). The mean number of pods per plant were

63 percent higher in *rabi* season compared to summer season (Table la and 2a). Among the varieties, 'JS-335' recorded significantly higher mean seed yield 1055 kg ha^{-1} in *rabi* and 998 kg ha^{-1} in summer over other two varieties, 'PK-1029' and 'MACS-450'.

In *rabi* season, 'PK-1029' variety recorded lowest yield (758 kg ha^{-1}) while in summer season variety 'MACS-450' recorded lowest yield (833 kg ha^{-1}) (Table 1b and 2b). Radhakrishna Murthy *et al.* (2001) reported superior performance of soybean varieties in winter than in summer season in Southern Telangana region of Andhra Pradesh.

Effect of sowing time

There was significant influence of sowing time on seed yield and number of pods per plant both in *rabi* and summer seasons. During *rabi*, crop sown on September 20th recorded significantly higher mean seed yield (1370 kg ha^{-1}) over other dates of sowing (Table 1b). Same trend was observed in mean number of pods/ plant which were maximum (70) with sowing on September 20th and significantly superior over other dates of sowing (Table la). There was 50 and 69 percent reduction in mean seed yield of soybean when the crop was sown on October 20th and October 30th, respectively compared to September 20th sowing (Table 1b). Similarly number of pods per plant also were reduced by 21 and 41 percent, respectively when sown on October 20th and October 30th compared to September 20th sowing. This reduction in seed yield and number of pods per plant might be due to the prevailing minimum low temperatures ranging between 15°C - 16°C which coincides with the reproductive phase of the crop growth in *rabi* season. Pramila Rani (1997) and Radhakrishan Murthy *et al.* (2001) reported that early sowing in October is favourable for soybean crop in Andhra Pradesh during *rabi*.

In summer, sowing on January 30th recorded mean seed yield of 1280 kg ha^{-1} which was at par with January 20th sowing (1247 kg ha^{-1}) but these were significantly superior over other dates of sowing (Table 2b). Similar trend was observed in mean number of pods per plant (Table 2a). Mean soybean seed yield was reduced by 45% and 70% when sown on February 9th and February 19th respectively (Table 2b). Similarly there was reduction in number of pods per plant by 26 and 33 percent when sown on February 9th and February 19th, respectively (Table 2a). Higher mean maximum temperature ranging between 36°C-37°C together with low relative humidity might have reduced the yields of soybean when sown beyond January 30th. A temperature of 26.5°C to 30°C appears to be optimum for most of the soybean varieties. Radhakrishna Murthy *et al.* (2001) reported similar results in January sowings for Southern Telangana Zone of Andhra Pradesh.

The duration of the varieties in *rabi* was 93-79 days, while delay in sowing upto October ending further reduced duration of the varieties to 79 days. In summer, the duration of the varieties was 91-87 days where sowing during February enhanced early maturity of the varieties (87 days) due to prevailing high temperatures, thereby reducing the yields.

Table 1a. Effect of varieties and dates of sowing on pods/plant

Variety	Sep 20	Sep 30	Oct 10	Oct 20	Oct 30	Mean
'JS-335'	77	77	60	61	45	64
'PK-I029'	54	51	45	45	37	46
'MACS-450'	79	62	58	59	43	60
Mean	70	63	54	55	41	57
	Sowing date	Variety	Varieties at the same date	Dates at the same or different varieties		
CD (P=0.05)	3.4	4.0	NS	NS		

Table 1b. Effect of sowing time and varieties on seed yield in *rabi* soybean (Mean of 2 years)

Variety	Sep 20	Sep 30	Oct 10	Oct 20	Oct 30	Mean
'JS-335'	1629(91)	1365 (88)	1168 (93)	765 (84)	347 (79)	1055
'PK-I029'	976 (91)	886 (88)	761 (93)	682 (84)	486 (79)	758
'MACS-450'	1504 (93)	1342 (90)	810 (94)	924 (84)	437 (79)	943
Mean	1370	1198	913	690	423	919
	Sowing date	Variety	Varieties at the same date	Dates at the same or different varieties		
CD (P=0.05)	38.0	95	212	177		

Table 2a. Effect of sowing time and varieties on number of pods/ plant in summer soybean (Mean of 2 years)

Variety	Jan 20	Jan 30	Feb 9	Feb 19	Mean
'JS-335'	23	23	18	17	20
'PK-1029'	20	22	21	14	19
'MACS-450'	34	27	17	18	24
Mean	25	24	19	16	21
	Sowing date	Variety	Varieties at the same date	Dates at the same or different varieties	
CD (P=0.05)	3.1	1.2	2.5	3.4	

Table 2b. Effect of sowing time and varieties on seed yield in summer soybean (Mean of 2 years)

Variety	Jan 20	Jan 30	Feb9	Feb 19	Mean
'JS-335'	1212	1479	831	468	998
'PK-1029'	1414	1098	637	378	882
'MACS-450'	1115	1164	654	301	833
Mean	1247	1280	707	382	904
	Sowing date	Variety	Varieties at the same date	Dates at the same or different varieties	
CD (P=0.05)	168	73	145	188	

Interaction effect

Interaction between varieties and time of sowing was significant for seed yield both in *rabi* and summer seasons. During *rabi*, soybean varieties 'JS-335' and 'MACS-450' gave on par mean seed yields when sown on September 20th and are significantly superior over other combinations. 'JS-335' sown on October 30th recorded lowest soybean seed yield of 347 kg ha^{-1} with 79 days duration (Table 1b).

In summer, soybean variety 'JS-335' sown on January 30th gave on par yields (1479 kg ha^{-1}) with 'PK-1029' sown on January 20th and these were significantly superior over other combinations. 'JS-335' and 'MACS-450' recorded lowest yield of 468 kg ha^{-1} and 301 kg ha^{-1}, respectively when sown on February 19th with 87 days duration (Table 2b).

It can be concluded that during *rabi* sowing on September 20th is more conducive with variety

'JS-335'. In Summer, sowing on January 30th with variety 'JS-335' is more favourable in vertisols of Adilabad, Andhra Pradesh, India.

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PRODUCTIVITY AND SUSTAINABILITY OF DIFFERENT CROP ESTABLISHMENT METHODS FOR CULTIVATION OF *RABI* RICE IN WESTERN ORISSA

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Abstract

A field experiment was carried out during *rabi* season of 2004-05 and 2005-06 to study sustainability of different crop establishment methods on growth and yield of transplanted *rabi* rice. Among the six crop establishment methods, raising rice crop by system of rice intensification method (SRI) resulted in significantly higher grain yield (6.09 t/ha) with better expression of yield attributes. Growing rice crop by system of rice intensification method recorded significantly more number of panicles (628m^{-2}), panicle weight (29 g) and filled spiklets panicle^{-1} (166).

Key words : Crop establishment, productivity, rice, sustainability.

In western Orissa *rabi* rice grown by conventional method of transplanting requires more water and labor which are expensive. Each kg of rice produced requires 3000 to 5000 liters of water which is becoming the single most constraint to produce more *rabi* rice in western Orissa. Scarcity of labour at peak period delayed rice transplanting by conventional method and resulted in low productivity of *rabi* rice (Lal *et al.*, 1982). Hence it needs to investigate on improving its water productivity and also to reduce the cost on labour for planting of *rabi* rice, and any capacity to produce more rice with less water will be an important contribution to sustainable water and food security. Keeping this in mind the present investigation was carried out to find out the suitable crop establishment method which may help the farmers in increasing the yield of *rabi* rice, to reduce cost on labour and also to increase water use efficiency for cultivation of *rabi* rice in western Orissa.

Materials and Methods

The experiment was conducted during the *rabi* season of 2004-05 and 2005-06 at Regional Research and Technology Transfer Station, Chiplima, Sambalpur. The soil of experimental field was sandy clay loam in texture having pH 6.4, organic carbon 0.48% and available nitrogen, phosphorus, potassium as 251,16.5 and 250 kg ha^{-1} respectively. The experiment comprising of 6 treatments, *viz.* standard practice of transplanting, system of rice intensification (SRI), integrated crop management (ICM), direct seeding with 8 row drum seeder at same day after puddling and manual broadcasting were evaluated in randomized block design with 4 replications. The variety 'lalat' was tested with recommended doses of N P K and Zn @ 120:60:60 and 25 kg/ha. Half of N and full dose of P, K and Zn was applid as basal and remaining half of N was applied in two equal splits at active tillering, and panicle initiation stage. Manual weeding was done at initiation of tillering and at active tillering. In system of rice intensification method, 10 days old seedlings were planted in the main field maintaining row to row spacing 20 cm and plant to plant 15 cm. For direct sowing, pre-germinated seed was sown in the main field by 8 row drum seeder. The leaf area was adjusted by multiplying with adjustment factor (k) at the respective growth stages. The data on weed count and dry weight of weed in rice was analyzed using square root (x+0.5) transformation. The leaf blade and shoot portions were dried separately in an oven at 70°C for 72 hours. The dry weights of leaf blades and shoot portions were used to compare dry matter accumulation. Observations on plant height, panicle number,

Table 1. Plant height and days to 50% flowering as influenced by crop establishment methods

Treatment	Plant height (cm)			Total tillers at harvesting/m^2			50% flowering (days)			Crop duration (days)		
	2004-05	2005-06	pooled	2004-05	2005-06	pooled	2004-05	2005-06	pooled	2004-05	2005-06	pooled
Standard practice of transplanting	104.6	106.3	105.4	541	553	547	110	113	111.5	139	142	140.5
System of rice intensification	108.5	110.4	109.4	659	685	672	99	102	100.5	130	132	131.0
Integrated crop management (ICM)	102.2	104.8	103.5	533	542	537.5	104	106	105.0	133	135	134.0
Direct seeding with 8 row drum seeder at same day after puddling	100.1	102.5	101.3	502	517	509.5	108	110	109.0	137	140.0	138.5
Direct seeding with 8 row drum seeder at one day) after puddling	102.6	105.1	103.8	513	530	521.5	107	109	108.0	134	136	135.0
Manual broad casting	99.4	103.6	101.5	494	507	500.5	105	107	106.0	133	134	133.5
CD(P=0.05)	4.1	5.0	4.8	46.9	50.2	41.8	6.8	5.4	6.2	8.2	7.8	9.2

Table 2. Yield attributing characters as influenced by different crop establishment methods

Treatment	Panicles/m^2			Panicle length (cm)			Panicle wt (g)			100 grain wt (g)		
	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled
Standard practice of transplanting	470	482	476	19.8	20.5	20.2	2.6	2.8	2.7	20.8	21.3	21
System of rice intensification	620	636	628	21.2	21.8	21.5	3.2	3.6	3.4	21.0q	21.6	21.3
Integrated crop Management (ICM)	455	467	461	19.2	20.1	19.7	2.7	2.5	2.6	20.6	20.1	20.4
Direct seeding with 8 row drum seeder at same day after puddling	434	448	441	18.6	19.6	19.1	2.4	2.7	2.5	19.8	20.2	20.0
Direct seeding with 8 row drum seeder at one day after puddling	445	459	452	19.0	19.9	19.5	2.2	2.5	2.3	20.0	20.4	20.2
Manual broad casting	424	438	431	18.4	19.3	18.8	2.0	2.3	2.1	19.2	19.8	19.5
CD(P=0.05)	44.2	48.3	42.6	4.2	5.4	2.9	0.4	0.2	0.1	NS	2.9	2.06

Table 3. Yield attributing characters as influenced by different crop establishment methods

Treatment	Spikelets/panicle			Filled spikelets /panicle			Un-filled spikelets /panicle			Spikelets fertility (%)		
	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled
Standard practice of transplanting	146.0	159.0	152.5	110	118.0	114.0	36.0	41.0	38.5	75.3	74.2	74.7
System of rice intensification	162.0	170.0	166.0	122.0	130.0	126.0	40.0	40.0	40.0	75.3	76.4	75.8
Integrated crop Management (ICM)	138.0	151.0	144.5	101.0	109.0	105.0	37.0	42.0	39.5	73.1	72.1	72.6
Direct seeding with 8 row drum seeder at same day after puddling	129.0	137.0	133.0	103.0	95.0	99.0	26.0	42.0	34.0	79.8	69.3	74.5
Direct seeding with 8 row drum seeder at one day after puddling	134.0	142.0	138.0	102.0	105.0	103.5	32.0	37.0	34.5	76.1	73.9	75.0
Manual broad casting	125.0	133.0	129.0	90.0	97.0	93.0	35.0	36.0	35.5	72.0	72.9	72.4
CD(P=0.05)	5.2	8.7	4.9	7.0	8.2	6.1	2.6	NS	1.06	7.2	6.9	2.1

Table 4. Grain yield, biological yield and harvest index as influenced by different crop establishment methods

Treatment	Grain yield (t/ha)			Straw yield (t/ha)			Biological yield (t/ha)			Harvest index		
	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled	2004-05	2005-06	Pooled
Standard practice of transplanting	5.10	5.38	5.24	5.95	6.79	6.37	11.05	12.17	11.61	46.15	44.20	45.18
System of rice intensification	5.98	6.20	6.09	6.34	6.55	6.44	12.32	12.75	12.53	48.53	48.62	48.57
Integrated crop management (ICM)	4.85	5.15	5.0	6.18	6.40	6.29	11.03	11.55	11.29	43.97	44.58	44.27
Direct seeding with 8 row drum seeder at same day after puddling	4.76	4.92	4.84	5.18	5.46	5.32	9.94	10.38	10.16	47.88	47.39	47.63
Direct seeding with 8 row drum seeder at one day after puddling	4.64	4.8	4.72	5.25	5.34	5.29	9.89	10.14	10.10	46.91	47.33	47.12
Manual broad casting	3.98	4.20	4.09	4.92	5.10	5.01	8.9	9.3	9.1	44.71	45.16	44.93
CD(P=0.05)	1.06	1.04	1.12	1.05	1.03	1.08	1.2	1.06	1.09	1.51	2.33	7.84

panicle weight 100 grain weight, biological yield, harvest index, grain and straw yield were recorded.

RESULTS AND DISCUSSION

Yield components

Among the six planting methods, system of rice intensification method recorded maximum panicle/m^2(628) with more panicle weight (3.4g) and panicle length (21.5cm), other treatments. It was also found that cultivation of rice crop by system of rice intensification recorded significantly more number of spikelets/panicle (166) and filled spikelets/panicle (126) as compared to other methods of rice planting (Tables 2 & 3).

Grain and straw yield

Data on grain yield (Table 4) indicated that planting of rice by system of rice intensification method recorded sigificantly higher seed yield (6.09 t ha^{-1}) and biological yield (12.53 ton ha^{-1}). It is probably due to more dry matter production per unit area caused by better nutrient absorption from soil, increased rate of metabolic process, rate of light absorption and increased rate of photosynthetic activity produced more number of leaves as compared to other crop establishment methods. It was closely followed by conventional method of transplanting which recorded grain yield of 5.24 t ha^{-1} and straw yield of 6.37 t ha^{-1}.

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GENETIC DIVERGENCE STUDY IN RELATION TO HETEROSIS IN TOMATO

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Abstract

Genetic divergence analysis was carried out in sixteen tomato genotypes. There was considerable diversity among genotypes for the quantitative and qualitative characters. The cluster V was the largest containing six genotypes followed by cluster I with four genotypes. The diversity among the cultivars measured by inter cluster distance and the higher order of divergence was recorded between cluster I and II, which was adequate for improvement of tomato by hybridization and selection. The genotypes like Type-I, Futesiro, KT-10 and KT-15 belonging to different clusters produced high heterosis for fruit yield per plant, thus can be used as promising parents for hybridization programme to obtain high heterotic response and better segregants in tomato.

Key words : Genetic divergence, heterosis, tomato.

Tomato (*Solanum lycopersicon* Mill) is widely cultivated vegetable throughout the world for fresh market and processing industry. The genetic improvement of tomato mainly depends upon the amount of genetic variability present in the population for quantitative and qualitative characters. The information on the nature and degree of genetic divergence for different characters would help the vegetable breeder in choosing the right parent for the development of variety. On other hand. with the success of commercial hybrid tomato in India, tomato breeders are currently interested in the exploitation of heterosis to increase the yield. To obtain heterosis in tomato, it is important to identify the extent of the level of parental divergence. Keeping these in view, the present investigation was carried out to know the nature and magnitude of important traits toward genetic diversity and relationship between parental genetic divergence and heterosis for fruit yield per plant in tomato.

Materials and Methods

Genetically diverse sixteen genotypes of tomato (H-24, Sikkim Local, FEB-2, Sel-2, KT-10, BT-207, BT-116-8-1, FEB-4, 97/640, BT-102-2-1, DVRT-2, Type-1, Flutesiro as lines and Flora-Dade, KT-15, BT-117-5-3-1 as testers) were transplanted in the *rabi* season of 2003-04 at Horticultural Research Farm, ICAR Research Complex for NEH Region, Umiam (Meghalaya) and crosses were made in line x tester mating design as method given by Kempthrone (1957). Twenty five days old seedlings of thirteen F_1's and sixteen parents were transplanted in well prepared field on *rabi* season of 2004-05 in randomized blogk desin with three replications at a spacing of 60 x 45 cm in plot size of 2.5 x 2.5 m consiting 23 plants in each plot. Uniform recommended cultural practices were followed. The data were subjected to D^2 analysis and clustering of genotypes was done by Tocher's method (Rao, 1952). Heterosis over better parent was also calculated.

Results and Discussion

The analysis of variances for each individual character showed highly significant differences among the genotypes for all the twenty characters. Sixteen genotypes were grouped into five clusters (Table 1). By using Tocher's procedure, among these, cluster V was the largest and consisted of six genotypes followed by cluster I with four genotypes. Cluster III had three genotypes whereas, cluster IV had two genotypes. The random distribution of genotype was evident from cluster V having maximum

Table 1. Grouping of genotypes in different cluster of parents

Cluster	Genotypes	Numbers	Source
I	97/640	4	ICAR RC NEH Region, Meghalaya
	BT-102-2-1		IIVR, Varanasi
	Flora-Dade		IIVR, Varanasi
	KT-15		IARI, Regional Centre, Katrain
II	Sikkim Local	1	ICAR NEH Regional Centre, Sikkim
III	FEB-2	3	IIVR, Varanasi
	KT-10		IARI, Regional Centre, Katrain
	FEB-4		IIVR, Varanasi
IV	Type-I	2	ICAR RC NEH Region, Meghalaya
	Futesiro		ICAR NEH Regional Centre, Nagaland
V	H-24	6	IIVR, Varanasi
	Sel-2		ICAR NEH Regional Centre, Manipur
	BT-207		OUA&T, Bhubneshwar
	BT-116-8-1		OUA&T, Bhubneshwar
	DVRT-2		IIVR, Varanasi
	BT-117-5-3-1		OUA&T, Bhubneshwar

Table 2. Estimate of average Intra & Inter cluster distance for five clusters of different genotypes of parents

Clouster	I	II	III	IV	V
I	2.83				
II	8.905	0.000			
III	4.550	8.788	2.887		
IV	5.332	7.220	4.961	1.794	
V	3.356	8.394	4.418	5.179	3.212

genotype with different distribution. The grouping pattern did not show any relationship between genetic divergence geographical diversity, which has been a point of debate in the past. Peter and Rai (1976) also opined that there was no apparent parallelism between genetic genotypes are presented in Table 2. The minimum inter cluster D^2 value (3.35) was observed between cluster I and V indicating the close relationship among the genotypes. Maximum inter cluster value was observed between cluster I and II (8.90), which indicated that the genotypes included in these cluster had maximum divergence. Hence, intermating between genotypes included in these cluster may give high heterotic response and thus better segregants.

There was a wide range of variation in the mean values for most of the characters under study (Table 3). These characters were grouped as genotype with higher fruit diameters, high juice and low acidity (cluster I); line with maximum plant height, minimum days to first flowering, higher fruit set percentage, minimum days to first and last picking, more number of fruits per plant, less number of locules, higher percentage fruit dry matter, higher TSS, higher acidity and ascorbic acid (Cluster II), plants which are less number of seeds per fruits, minimum ascorbic acid (cluster III); cluster IV contains higher fruit length and the last group contain high yielder with maximum number of branches, higher fruit weight, maximum nmber of seeds per fruit, higher pericarp thickness,

Table 3. Cluster mean for different growth, yield and quality parameters of parents

Characters	I cluster	II cluster	III cluster	IV cluster	V cluster
Plant height (cm)	48.96	99.07	49.40	80.04	49.21
No. of branches	5.20	6.66	5.66	6.85	6.86
Days to first flowering	63.24	57.65	71.57	71.92	62.32
Fruit set percentage	65.52	74.78	67.93	52.51	53.25
Days to first picking	86.35	86.12	101.64	95.50	88.54
Days to last picking	127.82	120.34	143.02	138.37	131.01
No of fruits/plant	18.66	46.33	21.59	16.51	24.66
Fruit length (cm)	4.18	2.99	4.55	4.57	4.56
Fruit diameter (cm)	5.11	2.98	4.58	3.67	4.49
Fruit weight (g)	47.50	14.01	39.96	42.08	50.72
No of seeds/fruit	82.13	66.68	51.35	77.19	82.84
No of locules/fruit	5.25	2.41	2.80	5.67	3. I I
Pericarp thickness (cm)	0.43	0.21	0.41	0.32	0.48
Fruit dry matter content (percent)	3.46	5.70	3.62	4.97	4.60
pH	5.04	4.61	4.81	4.67	5.19
TSS (%)	3.94	4.93	4.11	4.09	3.87
Juice (%)	62.36	52.47	51.01	56.65	60.11
Acidity (g)	0.77	1.08	0.83	0.96	0.86
Ascorbic acid (mg/I00 g)	27.63	43.09	23.78	32.50	25.33
Yield (kg/plant)	0.78	0.63	0.84	0.52	0.94

higher pH (Cluster V). This indicates while planning hybridization genotypes from diverse cluster I, II, III and V should be included as parents for desirable characters to get heterotic hybrids and better segregants in tomato. These findings are in accordance with the findings of Peter and Rai (1976), Gadekar *et al.* (1992) and Parthasarathy and Aswath (2002) in tomato.

The relationship between parental diversity and heterosis over better parents for fruit yield per plant are presented in Table 4 indicates wider parent diversity led to higher heterotic effects. The genotypes like Type-I, Futesiro, KT -10 and KT -IS belonging to different clusters produced high better parent heterosis for fruit yield per plant. High (up to 75.68%) heterosis for fruit yield per plant was obtained from those crosses where diverse parents were involved. It is mentioned here that Type-l, Futesiru (cluster IV) and KT-10 (cluster III) with KT-15 (cluster I) produced desirable recombinants for fruit yield per plant. Shrivastave and Arunachalam (1977) and Patnaik *et al.* (1991) also reported the parental diversity related to heterosis in triticale and rice, respectively.

Table 4. Relationship between parental diversity and heterosis for fruit yield per plant in tomato

Cluster No.	Parent (P_1)	Cluster No.	Parent (P_2)	F_1 fruit yield/plant	
				Hetersosis BP (%)	Rank
I	97/640	V	BT-117-5-3-1	-1.82	L
	BT-102-2-1		BT-117-5-3-1	18.18**'	M
Mean			8.18	i	
II	Sikkim local	I	Flora-Dade	36.08**/	H
	Sikkim local		KT-15	50.OO**',	H
Mean			43.04-\		
II	Sikkim local	V	BT-117-5-3-1	-6.36	L
Mean			-6.36		
III	FEB-2	I	Flora-Dade	53.61 **	H
	FEB-2		KT-15	-15.79*'	M
	KT-IO		Flora-Dade	-5.15 !	L
	KT-IO		KT-15	72.97*~1	H
	FEB-4		Flora-Dade	38.14*'	H
	FEB-4		KT-15	26.09*":	M
Mean			28.31		
III	FEB-2	V	BT-117-5-3-1	48.18**	H
	KT-IO		BT-117-5-3-1	30.00**	H
	FEB-4		BT-117-5-3-1	46.36**	H
Mean			41.51		
IV	Type-I	I	Flora-Dade	32~1	H
	Type-I		KT-I5	75.68*	H
	Futesiro		Flora-Dade	- 13.40'	L
	Futesiro		KT-15	70.27*	H
Mean			41.39:		
IV	Type-I	V	BT-117-5-3-1	34.55*t	H
	Futesiro		BT-117-5-3-1	29.09*!'	H
Mean			31.821		
V	H-24	I	Flora-Dade	38.14*t	H
	H-24		KT-15	57.69*f	H
	Sel-2		Flora-Dade	47.66*	H
	Sel-2		KT-15	22.43'	M
	BT-207		Flora-Dade	52.58""	H
	BT-207		KT-15	38.82*	H
	BT-116-8-1		Flora-Dade	54.64*	H
	BT-116-8-1		KT-15	43.68"'	H
	DVRT-2		Flora-Dade	43.43"'	H
	DVRT-2		KT-15	31.31 "I	H
Mean				43.04	

H= high, L= low, M= moderate

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EFFECT OF SPACING, SEED PLACEMENT AND PLANT DENSITY ON THE YIELD OF BABY CORN

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ABSTRACT

Increasing plant density, wider plant spacing and higher seed rate are essential for increased yield of baby corn. Considering baby corn ear yield, fodder yield, barrenness and lodging the plant population of 1, 33, 333 plants/ha with plant spacing of 60 cm x 12.5 cm and seed placement of 1 seed per hill is recommended.

Key words : Baby corn, plant density, plant spacing, seed placement.

Baby corn is young ear of corn plant (*Zea mays* L.) harvested just at the time of silk emergence (Prodhan *et al.*, 2006). The finger like young ear, dehusked and desilked is served as a specialized vegetable. Its delicacy, sweet flavor and crisp nature have increased its popularity in India and abroad, as a common ingredient of Manchurian (Chinese) and various fancy dishes (Chutkaew and Paroda, 1994). Its high economic return (Thakur, 2000) and value addition are also increasing its popularity in India day by day. Depending on agro-climatic conditions, 3-4 crops of baby corn can be taken from the same field in a year, giving good profit per hectare per season (Prasanna *et al.*, 1995). Optimum plant density which is an important factor for high yield of baby corn mainly depends on plant spacing (Kotch *et al.*, 1995). Information regarding spacing of plants and placement of seeds in determining optimum plant density is scantly. The present investigation was undertaken to find out the optimum plant density essential for high yield of baby corn, depending on plant spacing and seed placement.

MATERIALS AND METHODS

The total of six experiments (during *kharif* and *rabi* season in each year) were conducted separately during 2002, 2003 and 2004 at University Farm, BCKV, West Bengal and the analysis was made by averaging the data of six experiments. Randomized block design with four replications was followed in each trial consisting eight treatments with plant spacing, seed placement and plant density (Table 1). Each plot consisted of 5 rows of 5 m length each. Row to row distance was 60 cm and plant spacing was as per specification of the respective treatment (viz.25 cm, 12.5 cm, 8 cm, 6 cm or 5 cm). Seeds per hill were placed according to the specification of treatments (viz. 1, 2, 3 or 4 plants/hill).

Table 1. Treatments including plant spacing, seed placement and plant density in each trial

Treatment	Spacing	Seed placement	Plant density ha^{-1}
T_1	60 cm x 25 cm	1 plant/hill	66, 666 plants
T_2	60 cm x 25 cm	2 plants/hill	1, 32, 000 plants
T_3	60 cm x 25 cm	3 plants/hill	1, 98, 000 plants
T_4	60 cm x 25 cm	4 plants/hill	2, 64, 000 plants
T_5	60 cm x 12.5 cm	1 plant/hill	1, 33, 33 plant
T_6	60 cm x 8 cm	1 plant/hill	2, 08, 333 plants
T_7	60 cm x 6 cm	1 plant/hill	2, 77, 777 plants
T_8	60 cm x 5 cm	1 plant/hill	3, 33, 333 plants

Baby corn cultivar 'Early composite' was used in each trial. Cultural practices standardized by Prodhan (2003) were followed in each trial. Observations on the six characters were recorded in each trial.

RESULTS AND DISCUSSION

The results given in Table 2 revealed that with regard to plant spacing, 60 cm x 12.5 cm (T_5) ranked first (603.3 kg ha^{-1}) for standard yield (the most important baby corn ear yield character) followed by 60 cm x 25 cm) (T_1), 60 cm x 8 cm (T_6), 60 cm x 6 cm (T_7) and 60 cm x 5 cm (T_8) with the equal number of seed per hill (1 plant/hill). From the results it could be inferred that wider spacing upto a optimum level (60 cm x 12.5 cm) is desirable for higher yield of baby corn, which had conformity with the observation of Sukanya *et al.* (1999).

With the same plant spacing (60 cm x 25 cm) the seed placement for 2 plants per hill in T_2 gave highest standard baby corn ear yield (568.400 kg ha^{-1} followed by that of 1 plant per hill (T_1), 4 plants per hill (T_4) and 3 plants per hill (T_3), where standard yield of T_3 and T_4 was shown at par. Hence, it could be concluded that higher seed rate is essential for higher yield upto an optimum level, after that it is not effective.

With regard to plant density, standard yield of baby corn with the population of 1, 32, 000 plants ha^{-1} (T_2) was observed significantly higher (568.400 kg ha^{-1}) compared to that with the population of 66, 666 plants ha^{-1} which was, in general, recommended for field maize. Similar result of increased baby corn ear yield with the increasing plant density from normal plant density of yield maize was observed by a number of workers (Faiguenbaum and Olivares, 1995; Thakur *et al.*, 1997; Sahoo and Panda, 1999). It was found that, the yield level of T_2 and T_5 with the same plant populations was more or less same, and similar result was also obtained in between T_3 and T_6, and T_7. It was further observed that, standard yield of T_2 (1, 32, 000 plants ha^{-1}) and T_5 (1,33,333 plants ha^{-1}) was significantly higher in comparison with T_1 (66,666 plants ha^{-1}), but lower in T_3 (1,98,000 plants ha^{-1}) and T_6 (2,08,333 plants ha^{-1}). Thus, it could be inferred that, increased plant density upto optimum level is an important criteria in achieving high yield of baby corn, and further increase of it is certainly associated with linear decrease of yield.

The results revealed that with regard to husked yield (ear with husks) T_6 ranked first followed by T_7 and T_3; with regard to dehusked yield (ear without husks) T_6 ranked first followed by T_3; with regard to standard yield (selected ears without husks) T_5 ranked first followed by T_2 and T_1; with regard to fodder yield T_6 stood followed by T_4 and T_5. Besides, the barrenness

Table 2. Mean performance of baby corn cultivar for baby corn ear yield and other associated characters with regard to spacing, seed placement and plant density during *kharif* and *rabi* in the year 2002, 2003 and 2004

Treatment	Husked yield (kg/ha)	Dehusked yield (kg/ha)	Standard yield (kg/ha)	Fodder yield (kg/ha)	Barrenness (%)	Lodging (%)
T_1	3540	825	436	367	0	0
T_2	4220	990	568	410	2	0
T_3	4384	1225	251	440	10	3
T_4	3968	985	258	609	25	13
T_5	4355	1245	603	566	0	0
T_6	4948	1321	276	628	6	0
T_7	4445	1050	230	492	24	10
T_8	4125	836	205	489	31	24
SEm ±	49	38	21	43	4	3
CD at 5%	102	78	44	90	10	8

was lowest in T_1 followed by T_5 and T_2, whereas lodging was nil in T_1, T_5 and T_6. These indicate that none of the treatments is absolutely superior over all characters studied. However, considering all desirable characteristics under study T_5 (1,33,333 plants ha^{-1}; 60 cm x 12.5 cm; 1 plant/hill) was found to be the best treatment for baby corn production. Though the standard yield of T_5 and T_2 was at par, T_5 was identified as better one due to its less barrenness and lodging. Hence, the plant density of 1,33,333 plants ha^{-1}, plant spacing of 60 cm x 12.5 cm and seed placement of plant/hill are recommended for baby corn production.

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EFFECT OF WEED AND NUTRIENT MANAGEMENT ON DENSITY OF VARIOUS WEEDS AND YIELD OF CORIANDER (*CORIANDRUM SATIVUM* L.)

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ABSTRACT

Amongst eight weed species identified, only *Chenopodium murale* (L.) and *Spergulla arvensis* (L.) were found the most dominent. Two HW at 30 and 45 days after sowing and pendimethalin 1.0 kg/ha + HW at 45 DAS being at par, were found superior over rest of the treatments with respect to density of all weeds and coriander seed yield. Application of metribuzin 0.30 kg/ha at pre-emergence was found least effective in the control of various weeds and coriander seed yield compared to other treatments of weed management under test. Nutrient management involving N+P+K+S application though enhanced the density of all weeds as compared to N+P and N+P+K application, the difference was found statistically non significant. The balanced fertilization significantly increased the ssed yield of coriander with maximum at 60 kg N+ 30 kg P+ 30 kg K+ 30kg S/ha

Key words : Coriander, nutrient management, weed density.

Among the spices, coriander is cultivated in India in about 4.33 lakh ha and produces 31.8 lakh tones of seed. It is grown as commercial crop in many parts of the country. Area under this crop is increasing mainly due to industrial support with the growth of processing industries. It has been found to be a remunerative crop in *rabi* season and very economical crop in medicinal and aromatic plants based cropping systems. Coriander is cultivated under irrigated conditions and is subjected to vigorous competition with a variety of weeds which often inflict yield losses up to 60% and even more (Kushwaha *et al.*, 2002). Thus knowledge of important weed flora associated with this crop is essential to chalk out an effective weed programme. The present study was an attempt to have detailed account of prominent weeds associated with coriander under the influence of weed and nutrient management.

MATERIALS AND METHODS

A field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur, during *rabi* seasons of 2002-03 and 2003-04. The soil of the experimental field was clay loam in texture, slightly alkaline in reaction (pH 8.1), medium in available N & P and high in available K. Thirty three treatment combinations, consisting of 11 weed management treatments [weedy check, one hand weeding (HW) at 30 DAS, two HW at 30 and 45 DAS, pendimethalin 1.0 kg/ha, oxyfluorfen 0.25 kg/ha, metribuzin 0.30 kg/ha, oxadiargyl 75 g/ha, pendimethalin 1.0 kg/ha + HW at 45 DAS, oxyfluorfen 0.25 kg/ha + HW at 45 DAS, metribuzin 0.30 kg/ha + HW at 45 and oxadiargyl 75 g/ha + HW at 45 DAS] in main plots and 3 balanced fertilization treatments (N_{60} + P_{30}, N_{60} + P_{30} + K_{30} and N_{60} + P_{30} + K_{30} + S_{30} kg/ha) in sub-plots, were tested in split plot design with 3 replications. Coriander variety 'CS-6' was sown on 16th and 23rd October and harvested on 20th and 28th February in the respective seasons. The required quantity of test herbicides for each plot was calculated and solution of each herbicide was prepared using water at 800 l/ha. Herbicidal solutions were sprayed 2 DAS as pre emergence spray with the help of knapsak sprayer using flat fan nozzle. As per schedule hand weeding in the respective plots were done with hand hoe (Kudali). All the fertilizer nutrients *viz.* half dose of nitrogen and full doses of phosphorus, potassium and sulphur were applied as basal application before sowing as per treatment.

Remaining half dose of N was applied as top dressing at 30-32 DAS. Weed density recorded by counting the individual weeds presented in 2.25 m^2 area from each net plot ascertained by using 0.5 x 0.5m quadrate. In order to make data more valid, data of weed density were subjected to square root transformation using $\sqrt{X-0.5}$.

RESULTS AND DISCUSSION

Coriander was infested with eight spices of weeds belonging to seven different families, consisted of *Chenopodium murale* L., *Spergula arvensis* L., *Melilotus indica* L., *Anagallis arvensis* L., *Convolvuls arvensis* L., *Cyperus rotundlls* L. and *Cynodon dactylon* L. Out of these weeds *Chenopodium murale* L belonging to chenopodiaaceae, *Spergliia arvensis* L. belonging to cryophyllaceae and *Melilotus indica* L. were the most dominating dicot weeds responsible for deleterious effect on crop. It emerged out that these weeds had the fast growth right from the sowing of crop, make a thick mat on the soil surface, ceased growth after 60-70 days of their emergence and later on started decaying. These weeds together constituted 55.9 per cent of total weed density and *Chenopodium murale* alone shared 24.5 per cent (Table 1). Among monocots, density of *Cyperus rotundus* was found maximum during both the years. *Cyperus rotundus* L. have quick regeneration and survival capacity as well as greater competitive ability than the other weeds. It emerged comparatively late in the field and continued growth up to later stage of the crop growth. The extent of coriander seed yield under the influence of weed management treatments was inversely correlated with the increase in weed density while it increased with increase in fertility levels under the influence of nutrient management treatments.

Effect of weed management

Data on density of various weeds revealed that two HW (30 and 45 DAS) was found the most effective in controlling all weeds observed during the study. Pendimethalin 1.0 kg/ha as pre- emegence + HW at 45 DAS was found equally effective in controlling weeds as that of two HW. Both of these treatments gave significantly higher seed yield over rest of the treatments and increased the seed yield by 201 and 199 per cent, respectively compared to weedy check. The superiority of both these treatments might be due the fact that these treatments effectively controlled early as well as late flushes of weeds. Thus, reduced crop weed competition caused lesser drain of nutrients together with lesser competition to other growth factors. Results corroborate with the findings of Choudhary (2000) and Choudhary and Gupta (1991).

Two HW remained at par with pendimethalin 1.0 kg/ha as pre emegence + HW in reducing density of *Chenopodium murale, Melilotus indica, Anagallis arvensis, Convolvulus arvensis* and *Cyperus rotundus*. Further, pendimethalin + HW significantly reduced the density of *Spergula arvensis, Melilotus indica, Convolvulus arvensis*, and *Cynodon dactylon* over all herbicides tested with HW combination and remained statistically at par with oxyfluorfen 0.25 kg/ha + HW (45 DAS) in reducing density of *Chenopodium murale, Anagallis arvensis, Chenopodium album* and *Cyperus rotundus*. Pendimethalin being dinitroaniline, is known to be absorbed by germinating weeds and inhibits cell division in meristematic tissues so that most of weeds die within few days of their emergence. The superiority of pendimethalin over other herbicides could be ascribed to the fact that pendimethalin is less susceptible to degradation in soil system (Eshel *et al.*, 1979). It appears that the effect of this herbicide in suppressing the weed growth could be continuous for a longer time during crop growth period. High persistence of pendimethalin and its favorable effect on season long weed control has also been reported by Sharma (2001). Density of *Spergulla arvensis* and *Melilotus indica* was found significantly lower under oxadiargyl 75 g/ha + HW (45 DAS) compared to oxyfluorfen + HW. However, oxyfluorfen + HW found to significantly reduce the density of *Chenopodium murale, Anagallis arvensis, Chenopodim album, Convolvulus arvensis* and *Cynodon dactylon* over oxadiargyl + HW. Among all the herbicidal treatments metribuzin resulted in poorest weed

Table 1. **Weed density (No/m^2) and coriander seed yield (q/ha) as affected by weed and nutrient management (Pooled data of 2002-03 and 2003-04)**

Treatment	*Chenopodium murale*	*Spergulla arvensis*	*Melilotus indica*	*Annagallis arvensis*	*Cheno podium album*	*Convolvulus arvensis*	*Cyperus rotundus*	*Cynodon dactylon*	Seed yield (q/ha)
Weed management									
Weedy check	6.86 (46.58)	5.89 (34.23)	4.96 (24.31)	4.49 (19.68)	4.01 (15.57)	2.97 (8.35)	5.26 (27.22)	4.26 (17.77)	5.27
One HW (30 DAS)	2.38 (5.20)	2.36 (5.09)	2.39 (5.43)	2.31 (4.89)	2.15 (4.14)	2.35 (5.03)	2.76 (7.33)	2.39 (5.27)	12.31
Two HW (30 and 45 DAS)	1.85 (2.98)	1.76 (2.64)	1.88 (3.14)	1.73 (2.52)	1.49 (1.72)	1.56 (1.98)	2.35 (5.1 1)	1.43 (1.625)	15.84
Pendimethalin 1.0 kg/ha	2.21 (4.47)	2.51 (5.94)	2.63 (6.51)	2.17 (4.25)	2.08 (3.83)	2.13 (4.07)	3.54 (12.13)	2.36 (5.09)	10.40
Oxyfluorfen 0.25 kg/ha	2.56 (6.08)	2.81 (7.47)	3.08 (9.11)	2.24 (4.52)	2.14 (4.09)	2.18 (4.25)	3.65 (13.07)	2.43 (5.48)	8.99
Metribuzin 0.30 kg/ha	3.59 (12.48)	3.75 03.65)	3.25 00.29)	3.31 (10:52)	2.76 (7.14)	2.74 (7.08)	4.06 (16.04)	3.25 (10.16)	8.27
Oxadiargyl 75 g/ha	3.15 (9.61)	2.85 (7.65)	2.70 (6.97)	3.24 (10.15)	2.62 (6.39)	2.64 (6.49)	4.00 (15.64)	3.23 (9.94)	8.53
Pendimethalin 1.0 kg/ha + HW (45 DAS)	1.98 (3.50)	2.01 (3.64)	1.91 (3.26)	1.81 (2.86)	1.65 (2.26)	1.64 (2.20)	2.44 (5.62)	1.62 (2.19)	15.74
Oxyfluorfen 0.25 kg/ha + HW (45 DAS)	2.05 (3.79)	2.61 (6.37)	2.73 (7.10)	1.93 (3.27)	1.72 (2.50)	1.89 (3.17)	2.66 (6.78)	1.84 (2.91)	13.26
Metribuzin 0.30 kg/ha + HW (45 DAS)	2.96 (8.38)	3.11 (9.21)	2.87 (7.97)	2.49 (5.73)	2.51 (5.84)	2.31 (4.86)	3.06 (8.99)	2.39 (5.28)	12.48
Oxadiargyl 75 g/ha + HW (45 DAS)	2.58 (6.19)	2.32 (4.91)	2.25 (4.58)	2.44 (5.53)	2.45 (5.53)	2.20 (4.35)	2.94 (8.41)	2.28 (4.85)	12.77
CD (P=0.05)	0.21	0.17	0.33	0.18	0.13	0.17	0.32	0.23	0.80
Balanced fertilization kg/ha									
60 N + 30 P	2.91 (9.82)	2.85 (8.81)	2.75 (7.84)	2.52 (6.51)	2.32 (5.33)	2.22 (4.63)	3.32 (11.37)	2.48 (6.36)	10.33
60 N + 30 P + 30 K	2.92 (9.95)	2.90 (9.13)	2.79 (8.06)	2.55 (6.70)	2.32 (5.37)	2.23 (4.70)	3.33 (11.50)	2.50 (6.40)	11,25
60 N + 30 P + 30 K + 30 S	2.94 (10.02)	2.97 (9.55)	2.82 (8.28)	2.61 (6.95)	2.33 (5.42)	2.26 (4.81)	3.35 (11.52)	2.52 (6.47)	12.19
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	0.34

Figures in parenthesis are actual values control over weedy check especially at later stages which might be due to its high water solubility and less persistence in soil system. It is rapidly hydrolysed in water and susceptible to leaching losses (Rao, 2000). High pH of experimental soil (pH 8.1) also favoured its loss through leaching in to deeper soil layers. Another possible reason may be that this herbicide is less effective on grasses than dicot weeds (Tripathi, 1995). Under favourable moisture conditions recurrence of weeds takes place at much faster rate and this herbicide was unable to take care of later germinated weeds. Hence, the total weed control due to metribuzin was less.

The application of herbicides integrated with one HW at 45 DAS reduced total weed density and dry matter most efficiently during entire crop season compared to weedy check and individual herbicide application. This might be due to the fact that pre-emergence herbicide controls early flushes of weeds, while hand weeding destroyed mid-late flushes of weeds. Hence, crop-could remain weed free for comparatively longer duration than herbicide alone.

Effect of nutrient management

Data on weed density under the influence of nutrient management revealed that these treatments though increased the density of all weeds but failed to produced any significant difference in weed density of individual weed species at 60 DAS. Nutrient managament favourably improved the seed yield of coriander. The highest seed yield of 12.19 q/ha was obtained when crop was fertilized with N+P+K +S wherein significant improvement to the extent of 18 and 8 per cent was obtained by application of N+P and N+P+K, respectively. Overall improvement in crop yield under balanced nutrition of N, P, K and S seems to be on account of their potential role in modifying soil and cellular environment conducive for better development of growth parameters and ultimately higher seed yield. The results of present investigation are similar to the findings of Tripathi *et al.* (2001).

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EFFECT OF TEMPERATURE AND pH ON *FUSARIUM OXYSPORUM* F. SP. *PSIDII* CAUSING WILT DISEASE IN GUAVA

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ABSTRACT

Among the major production constraints in guava (*Psidium guajava* L.), wilt caused by *Fusarium oxysporum* F. sp. Psidii is very serious. The growth and sporulation of the fungus varied significantly at different temperatures and pH values. Maximum growth and sporulation was recorded at 25°C as compared to 30, 20 and 10°C. However, maximum growth and sporulation of the fungus was recorded at pH 7.0.

Key words : Temperature, pH, *Fusarium oxysporum* F. sp. *psidii*, guava wilt.

Guava (*Psidium guajava* L.), has good potential in fruit industry of our country because of its delicious taste, aroma, sweetness, flavor and balance amount of acid, sugar and pectin (Singh and Rao, 1996). Among the major production constraints, wilt caused by *Fusarium oxysporum* F. sp. *psidii* is very serious. The average loss due to this disease is estimated at about 30 per cent or sometimes even more (Dwivedi and Pandey, 1984). Losses due to the disease alone have made the cultivation of guava unprofitable to growers. It is well known that hydrogen ion concentration (pH) either in the food or in the habitat and a particular range of temperature affect growth and development of an organism. The knowledge of this aspect may be helpful in controlling pathogen causing disease in plants. Therefore, the present study deals with effect of temperature and pH on *F. oxysporum* F. sp. *psidii.*

MATERIALS AND METHODS

The experiment was conducted during 2002-03. In order to study the effect of temperature on the growth of *F. oxysporum* F. sp. *psidii*, potato dextrose agar (PDA) medium was used. *F. oxysporum* F. sp. *psidii*, the pathogen was isolated from wilted guava tree. The mycelia disc of the pathogen (15 day old culture) was cut with the help of 5 mm sterilized cork borer and transferred in centre of Petri plate containing PDA medium. Petri plates inoculated with fungus were incubated in a BOD incubator at 10, 15, 20 25 and 30°C for 10 days. Three replications were maintained for each temperature. The radial growth (cm) of the fungus was measured in two mutually perpendicular directions and number of spores per microscopic field was counted.

To study the effect of pH on the fungus, the pH of PDA medium was adjusted at 3, 5, 7, 9 and 11 by adding required amount of 0.1 N HCI or 0.1 N NaOH which was measured with the help of digital pH meter. Different sets were prepared by pouring 20 ml of PDA medium in each petri plate and after solidification inoculated with mycelial disc (5 mm in diameter) of the fungus. All the inoculated petriplates were maintained for each pH level. Petri plates inoculated with fungus were incubated in a BOD incubator for 10 days. The radial growth (cm) of the fungus was measured in two mutually perpendicular directions and number of spores per microscopic field was counted.

RESULTS AND DISCUSSION

The data given in Table 1 revealed that the growth and sporulation of the fungus varied significantly at different temperatures. The growth at 25°C was significantly maximum (9.03 cm) followed by at 30 and 20°C (7.00 and 6.16

Table 1. Effect of temperature on growth and sporulation of *F. oxysporum* F. sp. *psidii*

Temperature (°C)	Mycelial growth (cm)	No. of spores/microscopic field
10	2.16	7.00
15	3.10	10.50
20	6.16	19.66
25	9.03	25.00
30	7.00	0.0
CD (P=0.05)	0.22	0.43

Table 2. Effect of pH od PDA on growth and sporulation of *F. oxysporum* F. sp. *psidii*

pH of the medium	Mycelial growth (cm)	No. of spore/microscopic field
3.0	5.43	0.0
5.0	5.56	0.0
7.0	8.56	67.33
9.0	7.53	25.66
11.0	2.26	0.0
CD (P=0.05)	0.20	3.69

cm, respectively). There was poor growth at 10°C and 15°C (2.16 and 3.10, respectively). Maximum sporulation was recorded at 25°C followed by 20, 15 and 10°C. No sporulation was recorded at 30°C. Similar results were also reported by Schoeman (1995).

It is evident from the data given in Table 2, the growth and sporulation of the fungus varied significantly at different pH values of the PDA medium. The fungus grew at wide pH ranging from 3.0 to 11.0. The maximum growth of the fungus was observed at pH 7.0 (8.56 cm) followed by 9.0, 5.0 and 3.0 (7.53, 5.56 and 5.43 cm, respectively). Poor growth was recorded at pH 11.0 (2.26 cm). The maximum sporulation was observed at pH 7.0 (67.33) followed by pH 9.0 (25.66). No sporulation was recorded at pH 3.0, 5.0 and 11.0. These results are in accordance with those of Mathur *et al.* (1994) who reported that *F. oxysporum* F. sp. psidii grew and sporulated within a pH range of 4.5 to 7.8 with optimum growth and sporulation at pH 7.0.

Thus from the above findings, it can be concluded that the fungus (*F. oxysporum* F. sp. psidii) causing wilt in guava grows and sporulates fairly well at 25°C temperature and pH 7.0.

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STUDIES ON EFFECT OF SEEDBED CONFIGURATION ON PERFORMANCE OF SOYBEAN (*GLYCINE MAX* L.)-WHEAT (*TRITICUM AESTIVUM* L.) CROPPING SYSTEM IN THE NORTHERN PLAINS' ZONE OF INDIA

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Soybean is an important oilseed crop of rainy season in India. It occupies an area of 8.25 million ha with a total production of 8.67 million tonnes at an average yield of 1051 kg/ha (GOI, 2007). Its cultivation is mostly concentrated in the Central and Western India. However in recent years it is also making forays in the Northern Plains Zone of the country. Wheat is grown after the harvest of soybean. The soybean-wheat cropping system is gaining importance in many areas particularly where irrigation facility is limited and crops are grown utilizing the rain water. This soybean-wheat cropping system owing to lesser water requirement performs quite well. Further extending one or two irrigations during dry spells augment the productivity of this soybean-wheat cropping system. However, in years of scanty or high rainfall years, the crops suffer due to scarcity or excess of moisture, respectively. Soybean is highly sensitive to both scarcity and excess of moisture. Therefore it is necessary to devise ways of increasing the moisture use efficiency during scanty rainfall years as well as addressing the excess moisture in high rainfall years. Appropriate seed bed configuration has been reported to mitigate both these conditions. Measures to conserve as much as rain water during less rainfall years and ways of overcoming excess moisture conditions through appropriately designed land configuration tend to enhance the performance of soybean and succeeding wheat.

A field experiment was carried out during two consecutive years from 2001-02 to 2002-03 at the research farm of the Indian Agricultural Research Institute, New Delhi. The soil of the experimental field was alluvial sandy loam having 0.51% organic carbon and slightly alkaline in reaction (pH 7.4). The treatments consisted of 3 seed bed configurations viz. flat bed (FB), broad bed and furrow (BBF) and ridges and furrow (RF). The experiment was carried out in randomized block design replicated four times. Each treatment was imposed in 8 m long and 3. 6 m wide plot. All the treatments were applied with recommended dose of fertilizers. The different seed bed configurations were made using tractor mounted implement as per the treatments. In case of flat bed and ridges and furrow, a bund measuring 90 cm wide and 45 cm high were provided on either side of the plot. In ridges and furrow treatment, ridges were raised at 45 cm distance. In broad bed and furrow treatment, a 90 cm wide and 45 cm deep furrow was provided on either side of the bed. Soybean (variety 'PK 1042') seeds pre-treated with rhizobium (*Bradyrhizobium japonicum*) and phosphate solubilizing bacteria (*Pseudomonas striata*) was sown at 45 cm rows in all the seed bed configurations uniformly using a seed rate of 75 kg/ha during first fortnight of July in both the years of experimentation. After the harvest of soybean in second week of November, wheat (var. 'Kundan') was raised in the undisturbed layout with 22.5 cm row spacing using a seed rate of 100 kg/ha.

The ridges and furrow configuration recorded higher growth and yield parameters, and yield of both soybean and wheat during both the years followed by broad bed and furrow configuration, while during second year ridges and furrows sowing recorded significantly higher yield (Table 1) over flat bed, while, broad bed and furrow and flat bed sowing were at par with each other. Such positive effect of land configuration on the productivity of soybean have also been reported by Autkar (2006). The rooting depth and biomass in both soybean and wheat, nodule number and their biomass in soybean were higher in ridges and furrows followed by broad bed and furrow and flat bed configuration. On the basis of this 2 years' study it was concluded that under scanty and high rainfall condition, ridges and furrow configuration followed by broad bed and furrow configuration were better suited while during normal rainfall year both flat and broad bed and furrow planting were equally effective for soybean-wheat cropping system.

Table 1. Grain yield of soybean and wheat as influenced by planting method in soybean - wheat cropping system

Planting method	Grain yield (kg/ha)			
	2001-02		2002-03	
	Soybean	Wheat	Soybean	Wheat
Ridges and furrows	1921	3525	1725	4247
Broad bed and furrows	1780	3480	1607	4402
Flat bed	1575	3220	1540	3834
CD at 5%	184	171	132	242

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EVALUATION OF POST EMERGENCE HERBICIDES FOR WEED CONTROL IN LENTIL (*LENS CULINARIS* MEDIC.)

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Lentil is one of the important *rabi* pulse crops of India. Heavy infestation of weeds has become a serious problem for increasing and sustaining productivity of lentil. Weeds compete with plants for natural resources during cultivation and reduce the yield of lentil upto 87% (Punia *et al.*, 2003). The degree of reduction depends upon the density and duration of weed species and fertility status of soil. For weed control in lentil, herbicides like pendimethalin (PE) and fluchloralin (PPI) has been used commercially. There is no herbicide available for use as post-emergence thus, there is necessity of a herbicide which may be used as post-emergence, if a farmer has missed early application. In the north western plain zone of country where *Phalaris minor* is the major weed in *rabi* season such a new herbicide has great importance. In cognizance of the above, the present investigation was undertaken.

A field experiment was conducted during winter season, 2003 at Crop Research Center of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttaranchal), India. The soil of the experimental site was loamy in texture with neutral soil reaction (pH 7.4) having high organic carbon (0.80%), available phosphorus (32.1 kg ha^{-1}) and available potash (185.7 kg ha^{-1}). Ten treatments (Table 1) were evaluated in randomized block design with three replications. The sowing of lentil variety 'DPL-58' was done in rows 30 cm apart on December 3, 2003 and harvested manually on April 9, 2004. Fluchloralin (1000 and 750 g *a.i.* ha^{-1}) as per-plant incorporation, pendimethalin (1000 and 750 g *a.i.* ha^{-1}) as pre- emergence, fenoxzprop-p -ethyl (60 g *a.i.* ha^{-1}) at 35 DAS and clodinafop (40 and 60 g *a.i.* ha^{-1}) sprayed at 35 DAS.

The important weed species recorded in the experimental field were *Phalaris minor, Melilotus indica, Medicago denticulata, Coronopus didymus, Vicia sativa* and *Cynodon dactylon* etc. (Table 1).

The lowest density of weed at 60 DAS was found with pendimethalin 100 g followed by (fb) clodinafop 60 g *a.i* ha^{-1} except weed free. increasing dose of pendimethalin fb clodinafop had significant reduction in density of weeds as compared to its lower doses. Fenoxaprop-p-ethyl at 60 g *a.i.* ha^{-1} and clodinafop at 40 g *a.i.* ha^{-1} had more weed dry matter and weed density among the herbicide treatments. This may be due to more number of broad leaved weeds infestation. Yadav and Singh (1988), Malik *et al.* (2001) also reported the promising effect of these two herbicides in reducing the population of grassy weeds, but these were ineffective against broad leaved weeds.

All the treatment significantly reduced the total weed dry matter production as compared to weedy except fenoxaprop-ethyl at 60 g *a.i.* ha^{-1}, flucholralin at 1000 g *a.i.* ha^{-1}, cloclinafop at 60 g *a.i.* ha^{-1} pendimethalin at 1000 g *a.i* ha^{-1} and fluchloralin at 1000 g *a.i.* ha^{-1}. Among the herbicide treatments grain yield and straw yield was found highest in pendimethalin at 1000 g fb clodingafop at 60 g *a.i.* ha^{-1}. It was due to increased dose of pendimethalin fb clodinafop controlled most of weeds at different interval of crop growth. Fluchloralin was not as effective as pendimethalin in increasing the grain and straw yield of lentil. Superiority of pendimethalin over fhechloralin was also reported by Gautam (1982).

Table 1. Weed density, dry weight of weeds (60 DAS) grain yield and straw yield of crop as influenced by different weed control treatments

Treatment	Dose (g *a.i.* ha^{-1})	Weed density (No. m^{-2})	Weed dry wt (gm^{-2})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Fenoxaprop-p-ethyl	60	6.43 (623)	5.68 (343.48)	373	408
Clodinafop	40	6.40 (599)	5.13 (172.52)	312	508
Pendimethalin fb clodinafop	1000fb 60	4.35 (77)	3.92 (59.95)	755	1378
Pendimethalin fb clodinafop	750 fb 60	5.17(180)	4.94 (142.88)	501	744
Fluchloralin fb clodinafop	1000fb 60	5.66(287)	5.35 (210.61)	493	871
Fluchloralin fb clodinafop	750 fb 60	6.05(423)	5.72 (310.53)	426	645
pendimethalin	1000	4.73(115)	5.60 (274.32)	544	775
Fluchloralin	1000	5.66(291)	5.72 (310.60)	413	599
Weedy	-	6.67(791)	6.06 (434.40)	169	321
weed free	-	0.00(00)	0.0 (00)	1338	2008
LSD (P=0.05)		0.76	0.70	111.6	209.3

DAS= Day after sowing
Original values given in parentheses were subjected to loge (x+1) transformation before analysis

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COMBINING ABILITY AND HETEROSIS FOR GRAIN YIELD AND EAR CHARACTERS IN MAIZE

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ABSTRACT

Combining ability analysis was conducted using line x tester design in maize inbred lines for yield and yield contributing traits. The sca variance was observed to be more important for all the traits studied. The inbreds DMR-201, CM-119 and CM-121 were good general combiner for grain yield per plant and most of their yield contributing traits. These parents should be extensively used in the crossing programme to exploit maximum genetic variability and isolate transgressive segregant for grain yield and its components. The Cross CM-121 x DMR-201 showed high sca effects and heterosis for its consistent performance over the wide range of environments. Other crosses viz., CM-119 x DMR-40E, CM-104 x AML-420 and CM-119 x DMR-201 also showed high better parent heterosis and significant sca effects for grain yield.

Key words : Heterosis, grain yield, ear character, combining abiliy, maize.

Maize (*Zea mays* L.) is third most important cereal crop in India next to rice and wheat. It is gaining significant importance on account of its growing demand for diversified end uses, especially feed and industrial uses. The improvement in vigour and yield potential of inbred lines and development of better cultural practices, single crosses were adopted for commercial cultivation. The recent trend is to go for single crosses than for double crosses, as the single crosses are the highest yielders under most favorable environments, show higher uniformity than the double and three way crosses. Moreover, seed production in single crosses involves lower cost than do the double crosses. The information about the heterotic patterns and combining ability of the parents and crosses both, facilitate the breeders in the selection and development of the single cross hybrids. Keeping these situations in view, an attempt was made to develop single crosses through Line x Tester analysis.

MATERIALS AND METHODS

Ten elite inbred lines of maize *viz.*, CM-104, CM-105, CM-114, CM-115, CM-118, CM-119, CM-120, CM-121, CM_130 and CM-131 lines were crossed with four testers viz., KI-109, DMR-40E, AML-420 and DMR-201 during *kharif*-2005 at Maize Research Station, Amberpet, Hyderabad to generate 40 crosses. Theses. These 40 crosses along with 14 parents and 2 standard checks (DHM-103 and DHM-105) were raised in randomized block design with three replications in experimental field at College farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi* 2005-06. Each entry was raised in single row of 5 meter length with a spacing of 75 x 20 cm. Five competitive plants from each genotype were randomly selected from each replication for recording biometrical observations ear length (cm), ear girth (cm), number of seed rows per ear, number of seeds per row, number of seeds per ear, 100-seed weight (g), and grain yield per plant (g). Line x tester analysis was carried out according to Kempthorne (1957).

RESULTS AND DISCUSSION

The variance due to males was significant for all the traits. Where as, variance due to

Table 1. Mean sum of squares of females, males and female x male interactions and gene actions in respect of selected quantitative characters in maize

Source of variation	D.f	Ear length (cm)	Ear girth (cm)	Number of seed rows per Ear	Number of seeds per row	Number of seeds per Ear	100 Seed weight (g)	Grain yield per Plant (g)
Replication	2	0.060	0.032	0.074	0.404*	53.433	0.190	13.638
Females	9	7.420	2.231	2.362	32.385	13279.307*	10.863	1304.227
Male	3	52.114**	101.751**	49.156**	641.824**	220267.777**	11.595**	11869.578**
Female x Male	27	3.478**	3.642**	2.810**	17.330**	5290.694**	13.026**	813.220**
Error	106	0.224	0.061	0.096	0.099	29.314	0.75	9.105
σ^2 gca		5.9244	0.0763	0.1185	0.0568	0.8455	301.6957	0.4950
σ^2 sca		33.6155	1.0847	1.1937	0.9046	5.7438	1753.7866	4.2516
σ^2 gca / σ^2 sca		0.1762	0.0703	0.0992	0.0627	0.1472	0.1720	0.1164
Degree of dominance $\sqrt{\sigma^2 \text{ sca} / 2\,\sigma^2 \text{ gca}}$		1.6843	2.6654	2.2439	2.8213	1.8430	1.7049	2.0722

* Significant at 5 percent level; ** Significant at 1 percent level

females were non- significant for all the traits except number of seeds per ear. The femal x male interaction variances were highly significant for the characters. The analysis of variance (Table 1) revealed higher proportion of σ^2 sca than σ^2 gca also indicates that the additive x non additive interactions were significantly higher among the hybrids, which would be important for their exploitation. Higher sca variance than gca variance exhibiting preponderance of non-additive gene effects has also been earlier reported by Singh and Mishra (1996), Venkatesh *et al.* (2006) and Lata *et al.* (2008).

The variance components of general combining ability (gca) and specific combining ability (sca) were significant for the characters, indicating the role of both additive and non-additive gene actions in the inheritance of these characters. Since both additive and non-additive gene actions were important in controlling the characters studied, hybridization methods, and such as, multiple or reciprocal recurrent crossing, which exploits both additive and non-additive gene effects simultaneously, could be useful in the genetic improvement of the characters studied.

The gca estimates (Table 2) revealed that the line, CM-119 was the best general combiner for most of the characters followed by CM-121 and CM-130. Among testers, DMR-201 was good general combiner. These lines showed high gca effect for grain yield and its component characters could b utilized extensively in hybridization programme with tester; DMR-201 to exploit maximum genetic variability and isolate transgressive segregants for grain yield and its components. In bred KI-109 and CM- 104 were poor general combiners for grain yield as it tended to bring about significant increase in this character. For ear length, CM-115, CM-121 and DMR-201 (tester), for number of seed rows per ear, number of seeds per row, number of seeds per ear CM-119, CM-121, CM-120 (lines), and DMR-201(tester) and for 100 seed weight CM-119, CM-105 and DMR-201 (tester) were recorded good general combing ability and two in breds KI-10 and AML-420 were recorded very poor general combining ability for most of the

Table 2. General combining ability effects of selected parents in respect of selected quantitative traits in maize

Genotypes	Ear length (cm)	Ear girth (cm)	Number of seed rows per Ear	Number of seeds per row	Number of seeds per Ear	100 Seed weight (g)	Grain yield per Plant (g)
Parents							
Lines							
CM-104	-1.509**	0.138**	-0.051**	-2.722**	-26.176**	0.529**	-14.068**
CM-105	0.332**	0.013	-0.493**	-0.763**	-26.142**	1.279**	-9.751**
CM-114	-0.560**	-0.439**	-0.484**	-1.913**	-31.189**	-3.171**	-12.343**
CM-115	1.061**	0.673**	0.549**	0.562**	18.144**	0.471**	1.424
CM-118	-0.301**	-0.394**	-0.451**	-0.613**	-18.902**	-0.738**	0.449
CM-119	0.434**	0.357**	0.541**	2.528**	66.903**	3.313**	18.341**
CM-120	-0.114**	-0.363**	0.566**	2.012**	25.772**	-0.904**	2.374
CM-121	1.030**	0.635**	0.249**	1.062**	31.253**	0.613**	12.516**
CM-130	0.210**	-0.299**	-0.318**	0.353**	-16.082**	-0.371**	4.491*
CM-131	-0.584**	-0.321**	-0.109	-0.505**	-23.581**	-1.021**	-3.434**
Testers							
KI-109	-1.530**	-1.849**	-1.339**	-4.318**	-73.089**	-3.159**	-15.539**
DMR-40E	-0.005**	0.711**	0.051**	2.338**	15.713**	0.687**	-3.063**
AML-420	-0.153**	-1.105**	-0.426**	-3.375**	-57.312**	-2.483**	-10.233**
DMR-201	1.688**	2.243**	1.714**	5.355**	114.688**	4.954**	28.834**

* Significant at 5 percent level; ** Significant at 1 percent level

Table 3. Mean per se performance (MPP), specific combining ability effects and heterobeltiosis of selected single cross hybrid of maize

Characters		CM-104 x AML-420	CM-104 x DMR-201	CM-115 x DMR-201	CM-118 x DMR-201	CM-119 x DMR-40E	CM-119 x DMR-201	CM-121 x DMR- 201
Ear Length (cm)	Per se	9.460	11.323	15.517	12.043	11.490	12.643	16.333
	sca	-0.041	-0.018	1.605**	-0.506	-0.102	-0.642*	2.452**
	heterosis	-9.24*	-20.52**	8.91**	-15.47**	-13.50**	-11.25**	14.65**
Ear Girth (cm)	Per Se	12.393	14.543	16.440	14.393	13.337	15.440	17.570
	sca	1.045**	-0.153	1.209**	0.229**	-0.047	0.525**	2.377**
	heterosis	31.29**	2.27	15.61**	1.22	26.33**	8.58**	23.56**
Number of Seed Rows per Ear	Per Se	10.933	12.200	14.800	13.800	11.767	14.033	15.467
	sca	0.034	-0.839**	1.161**	1.161**	-0.201	-0.402*	2.128**
	heterosis	6.84**	-7.58**	12.12**	4.55*	-0.84	6.31**	17.17**
Number of seeds per row	Per Se	18.833	22.733	31.800	28.533	27.933	30.900	32.467
	sca	2.358**	-2.472**	3.312**	1.220**	0.495**	0.445*	3.478**
	heterosis	37.14**	20.28**	68.25**	50.97**	57.52**	63.49**	71.78**
Number of Seeds per Ear	Per Se	229.207	307.807	496.327	407.480	342.993	465.613	520.980
	sca	35.651**	-57.749**	86.452**	34.651**	-16.666**	6.979*	97.996**
	heterosis	49.22**	9.62**	76.76**	45.12**	48.68**	65.83**	85.55**
100 Seed weight (g)	Per Se	25.500	26.633	31.933	28.600	24.667	30.700	33.567
	sca	3.991**	-2.313**	3.046**	0.921**	-0.796**	0.971**	4.538**
	heterosis	23.59**	1.40	21.57**	8.88**	5.11**	16.88**	27.79**
Grain Yield per plant (g)	Per Se	66.500	65.600	138.433	132.800	110.200	135.333	139.000
	sca	14.591**	-25.376**	31.966	37.308	18.713**	11.949**	21.441**
	heterosis	55.01**	7.72	127.31**	118.06**	102.33**	122.22**	128.24**

* Significant at 5 percent level; ** Significant at 1 percent level

characters studied. The parents having high gca effects would be useful since the gca effect is due to additive gene action and is fixable. (Sprague and Tatum, 1942). Thus, inbreds DMR-201, CM-119 and CM-121 were good general combiners for grain yield per plant and most of their yield contributing traits.

A perusal of first seven best hybrid revealed that the crosses CM-121 x DMR-201, CM-119 x DMR-40E, CM-104 x AML-420 and CM-119 x DMR-201 Performed best on the basis of high sca effects for grain yield coupled with high better parental heterosis. Selecting a cross combination for hybrid production only on the basis of sca effects most of the times may not meet the desired goal. Those crosses with significant positive sca and better parent heterosis could fruitfully be exploited for hybrid production. Sathyanarayana *et al.* (1994), Sedhaom (1994), Shahi and Singh (1986) also opined the importance of sca for exploitation of hybrid production. Some of the parents involved in the crosses indentified as promising were medium x high, low x high and high x poor general combiners for grain yield and its component characters. This indicated that non-additive type of gene actions, which are non-fixable, were involved in these crosses. Therefore, the crosses CM-121 x DMR-201, CM-119 x DMR-40E and CM-104 x AML-240 are suited to be directly used in hybrid production in order to utilize the hybrid vigour expressed in F1 instead of going for selecting sergeants in advanced generations. The results of the present study suggest that heterosis coupled with high sca effects may be considered as criterion for selecting the best cross combination for further improvement of grain yield in maize.

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HETEROSIS IN SCENTED RICE (*ORYZA SATIVA* L.) FOR YIELD AND SOME QUALITY CHARACTERS

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ABSTRACT

The present study was carried out during *kharif*, 2006, 2007 and 2008 for identification of restorers and maintainers in diverse rice genotypes and development of fertile rice hybrids. Two CMS lines, IR68890 A and IR68281 A were crossed with 25 diverse rice genotypes, and resultant 50 hybrids were evaluated for pollen and spikelet fertility, based on pollen and spikelet fertility index, 11 and 9 restores were identified for IR68890A and IR68281A, respectively. Similarly, 4 maintainers in each were identified for both the CMS lines. Identified restorers used to develop experimental rice hybrids, and maintainers can be used to develop new CMS lines in scented rice backgrounds through repeated back crossing. The standard heterosis in 20 rice hybrids were estimated over HUR-36 and Pusa Basmati-1 for yield and quality characters, respectively. Over all three hybrids, IR68890 Ax Khao Hawn, IR 68890A x PB-7-16-57-3 and IR68281 A x PB-4-18-57-6 were identified superior over HUR-36 and Pusa Basmati-1 for most of the yield and quality characters respectively. These hybrids can be utilized commercially after further evaluation.

Key words : Restorers , maintainers, heterosis, scented rice, yield and quality characters.

Rice is the important staple food provides nourishment to more than 60% of the world's population. Our rice productivity has stagnated since last two decades (Mahadevappa, 2004). Ever increasing population required more rice in coming years, it is expected to be 160 mt by 2015. Increasing living of standard of people also demands superior grain quality. Therefore, our scientists faced a great challenge to achieve above goals even in the changed environments. The options are limited to increase rice productivity, now-a-days one option hybrid technology is being used to this direction. After successful utilization of hybrid rice in China for the substantial yield increase encouraged our scientists to develop rice hybrids with acceptable grain quality. The first step of hybrid breeding programme is identification of restorers and maintainers in given genotypes, seconds is evaluation of parents on the basis of per se performance and combining ability of hybrids, and third is hybrid seed production by using the best parents, Hence, the present study has been planned isolate restorers and maintainers in rice genotypes and their use in development of experimental rice hybrids.

MATERIALS AND METHODS

Identification of restorers and maintainers

The experimental material consists of 25 diverse rice genotypes and 2 CMS lines, IR68890A and IR68281A. The crosses were made between CMS lines and rice genotypes at Agricultural Research Farm of Amar Singh (P.G.) College, Lakhaoti (Bulandshahr) during *Kharif*, 2006. The resultant 50 hybrids were germinated in petriplates with moist germination paper after disinfecting them by treating with 0.2 percent mercuric chloride solution for about a minute and then washing in running water. Five to Six days old seedlings were transplanted in the main field during *Kharif*, 2007 using randomized block design (RBD) with two replications at the spacing of 20 x 15 cm with row length of 1.5m. The standard agronomic practices were used to raise normal crop. Five testing pollen fertility. Florets collected from top, middle and bottom portion of each selected panicle and pollen grains were stained with 1% iodine solution. Total 300 pollens were observed for pollen fertility. Spikelet fertility were estimated from five

Table 1. Pollen and Spikelet Fertility of F_1 Rice Hybrids

	Against IR 68890A			Against IR 68281 A		
Genotype	Pollen Fertility (%)	Spilelet Fertility (%)	R/PR/ PM/M	Pollen Fertility	Spilelet Fertility (%)	R/PR/ PM/M (%)
Dev Leuan	96.4	88.3	R	70.3	64.6	PR
Patloon tahni	0.0	4.0	M	54.3	45.7	PR
Domsiah	90.6	89.7	R	19.4	13.7	PM
Basmati Champaran	89.4	86.2	R	0.5	0.0	M
Prasad Bhog	75.8	66.3	PR	95.6	88.7	R
Khao Dawak Mali-105	16.4	12.8	PM	71.3	67.6	PR
Basmati-134	94.3	85.2	R	91.9	86.8	R
AC-25419	38.2	32.8	PR	89.3	84.6	R
Basmati Sathi	68.7	57.3	PR	16.8	19.2	PM
Gopal Bhog	18.5	9.7	PM	76.7	69.5	PR
Khao Hawn	96.3	89.2	R	13.4	9.8	PM
Seeta Sail	0.0	0.0	M	0.9	0.0	M
KCN-80152	54.4	42.8	PR	98.0	91.2	R
PB-6-12-55-5	0.9	0.0	M	72.6	68.3	PR
PB-3-17-58-2	89.9	91.2	R	56.5	48.6	PR
PB-8-48-59-2	16.5	8.7	PM	69.2	64.6	PR
PB-3-17-57-1	93.6	86.7	R	14.6	8.8	PM
PB-6-12-24-4	35.4	41.3	PR	90.2	87.4	R
PB-7-16-57-3	90.5	88.6	R	14.6	8.8	PM
PB-6-12-24-4	35.4	41.3	PR	90.2	87.4	R
PB-7-16-57-3	90.5	88.6	R	0.0	0.0	M
PB-17-4-5-63-3	19.2	13.6	PM	74.0	68.6	PR
PB-6-1-60-9	0.0	0.0	M	85.6	87.2	R
PB-5-14-50-1	89.6	94.2	R	0.0	0.4	M
PB-3-17-32-2	91.4	88.5	R	96.7	86.3	R
PB-6-4-60-7	16.7	9.5	PM	93.5	89.8	R
PB-4.18-57-6	92.7	85.6	R	89.6	92.4	R

R=Restorers, PR= Partial Restores, PM= Partial Maintainer, M= Maintainer

randomly selected bagged panicles, at maturity stage, harvested panicles were counted as filled and unfilled grains. Genotypes were classified on the basis of fertility index as given by Pradhan *et al.* (2006), as effective restorers (> 80 % pollen and spikelet fertility), partial restorers (21-79% pollen and spikelet fertility), partial maintainers (11-20% pollen and spikelet) and effective maintainers (0-10% pollen and spikelet fertility). After the identification of restorers again crosses were made to develop fertile rice hybrids for heterosis studies.

Heterosis studies

Twenty rice hybrids along with checks, HUR-36 and PB-1 were planted in a randomized block design (RBD) with three replications during *Kharif*, 2008 at the same research farm adopted a spacing fo 20 x 10 cm with row length of 3m for each replication. The yield of hybrids was compared with HUR-36, whereas quality characters compared with Pusa Basmati-1. Ten randomly selected plants from each replication for each entry were used to record the observations on days to maturity, plant height, number of panicles plant^{-1}, grains panicle^{-1}, test weight and grain yield plant^{-1}, whereas bulked seeds of 10 randomly selected plants were used to analyze quality characters like head rice recovery, kernel length, breadth, L/B ratio,

Table 2. Estimates of standard heterosis for yield and quality characters in rice hybrids

	Satandard Hetrosis over HUR-36						Standard Herosis over Pusa Basmati-1						
Cross	DM	PH	NPP	GP	TW	GYP	HRR	KL	KB	L/B	AC	GC	VE
IR 68890AX daev Luana	-0.98	-2.74	25.7*	1.75	-11.36	18.03*	35.03**	2.97	10.53*	-7.09*	-7.70	33.17**	25.71**
IR 68890AX Khao Hawan	-3.21	-17.90	70.7**	39.30**	28.18*	95.54**	29.80*	-11.79*	13.98*	-10.97	13.16*	16.83*	18.83*
IR 68890AX Basmati-134	-18.14*	-15.20*	38.00**	10.07	16.36**	71.88**	16.83**	-5.05	16.39*	-15.58**	14.58*	-31.07*	-2.85
IR 68890AX Basmati Champaran	-1.98	2.44	13.17*	4.92	0.90	65.72**	-9.02	-9.72*	12.87*	-18.59**	-16.08	-95.12**	8.52
IR 68890AX Domsiah	-3.21	-7.79	19.94	6.24	5.00	12.59	24.14**	-12.31	3.51	-15.49**	-5.54	11.21	11.42
IR 68890AX PB-3-17-58-2	-4.74	-7.65	8.74	6.91	10.34	9.34	11.62*	-4.53	21.03**	-11.24*	-7.70	-10.63*	2.85
IR 68890A PB-3-17-57-1	-19.33*	-21.85**	41.17**	17.85**	-3.18	55.47**	5.41	-7.39*	17.54**	-19.46**	-3.25	2.44	7.52
IR 68890AX PB-7-16-57-3	-18.59*	-17.16**	57.64**	25.30**	32.72**	72.7**	22.84**	-1.94	13.45**	-13.72*	15.54*	14.63*	15.71*
IR 68890AX PB-5-14-50-1	-20.81*	-25.24**	10.94	7.00	-6.36	10.48	9.61*	-12.43**	15.19*	-14.12*	-18.50	4.88	11.42
IR 68890AX PB-3-17-32-2	-8.35	19.40*	1.97	18.64	21.21**	44.75**	9.93*	-0.91	21.64**	-18.81*	2.50	43.41**	31.67**
IR 68890AX PB-4-18-57-6	-1.5	-4.53	19.17*	6.02	4.09	19.68*	14.02*	0.39	15.77**	-13.5*	-5.16	56.1**	13.24*
IR 68281AX Prasad Bhog	-0.99	17.42*	20.11*	6.13	11.81	25.71**	25.62**	-5.57	4.66	-9.95*	-13.75*	38.53**	5.71
IR 68281AX Basmati-134	-2.5	17.15*	-10.58	4.38	18.18**	-5.03	21.04**	-5.76	8.77	11.73**	-2.41	2.44	51.42**
IR68281AX AC-25419	-0.74	-22.70**	21.29**	1.42	3.63	26.94*	20.14**	-4.89	26.34**	-10.12**	-22.41**	89.51**	-5.71
IR 68281AX KCN 80152	-2.72	18.52*	7.41	16.64*	15.00*	10.66*	-1.80	2.49	11.7*	-10.63**	-0.54	-2.44	4.25
IR 68281AX PB-6-12-24-4	-1.24	-1.72	17.52*	12.15*	14.51*	34.85**	29.25**	-9.59*	14.04*	-13.02**	-12.12**	82.51**	5.71
IR 68281AX PB-6-1-60-9	-1.98	-22.51**	44.11**	17.66*	33.18*	54.01**	16.02**	5.05	8.19	-3.10	-3.10	99.72**	62.35
IR 68281AX PB-3-17-32-2	-2.72	3.88	10.58	12.70	7.75	32.27**	-8.81	-12.69**	-16.96*	-15.44**	-22.37**	1.42	2.85
IR 68281AX PB-6-4-60-7	-1.48	-1.80	-4.47	9.20	0.15	4.74	25.05**	-8.55**	3.51	-11.95**	-0.91	93.41**	3.42
IR 68281 AX PB-4-18-57-6	-5.0	29.03**	10.35*	39.97**	27.77**	76.61**	25.85**	-4.79	21.03**	-15.46**	-18.87*	53.41**	57.14**
SE(±)	2.58	3.89	1.54	0.97	1.35	3.47	2.69	0.38	0.92	0.23	1.75	7.98	0.76

* ** Significant at 5% and 1% level, respectively; DM-Days to maturity, PH=Plant height, NPP= Number of panicles per plant, GP=Grains per panicle, TW=Test weight, GYP= Grain Yield per plant, HRR= Head rice recovery, KL= Kernel length, KB = Kernel breadth, L/B = Kength breadth ratio. AC= Amylose content, GC= Gel consistancy, VE= Volume expansion.

amylase content, gel consistency, volume expansion and aroma. All the yield and its component characters were measured as per standard evaluation system of chaudhary (1996), and quality characters estimated as per standard methods given by singh *et al.* (2000).

RESULTS AND DISCUSSION

The pollen and spikelet fertility of hybrids are presented in Table1. The crosses with IR 68890A showed 0.0 to 96.4% and 0.0 to 94.2% pollen and spikelet fertility, respectively, crosses with IR 68281 A showed 00.0 to 98% and 00.0 to 92.4% pollen and spikelet fertility, respectively. On the basis of pollen and spikelet maintainers and 4 effective maintainers were identified for IR 68890A. Similarly, 9 restorers, 8 partial restorers, 4 partial maintainers and 4 effective maintainers were identified for IR 68281A. In the present investigation, some genotypes behaved as restorers for one CMS line and maintainers or partial maintainers for another CMS line, this is due to nuclear gene interactions in different ways.

The standard heterosis of rice hybrids are presented in Table 2. Out of 20, 4 hybrids, IR68890A x Basmai-134, IR68890A x PB-3-17-57-1, IR68890A x PB-7-16-57-3 and IR68890A x PB-5-14-50-1 exhibited significant negative standard heterosis for days to maturity, which matured earlier than the HUR-36. For plant height, 6 hybrids exhibited negative standard heterosis and these are shorter in height than HUR-36. Similar findings were also presented by serial *et al.*, (2006). Panicles plant-1 is important yield component, 12 hybrids showed significant positive standard heterosis for this character. These results are in conformity with Rosamma and Vijay Kumar (2005). Out of 25, Seven hybrids exhibited significant positive standard heterosis for grains panicle^{-1}. Similar findings were also given by Gnanasekaran *et al.* (2006). For test weight, positive as well as negative standard heterosis were observed in rice hybrids, nine hybrids exhibited significant positive standard heterosis for test weight. These results are in conformity with Rosamma and Vijay Kumar (2007). For grain yield, 15 hybrids exhibited significant positive standard heterosis, Similar results were also reported by Gnanasekaran *et al.*, (2006).

The head rice recovery is important quality character for miller as well as traders, out of 25, 16 hybrids exhibited significant positive standard heterosis over Pusa Basmati-1 for this character. The grain size and shape (kernel length, kernel breadth and L/B ratio) is important quality charcter but none of the hybrid shown superiority over PB-1 for these characters, however, hybrids were found to be nearly at par with PB-1 for grain size and shape. These hybrids were included, IR 68890A x PB-3-17-57-1, IR68281A x PB-6-4-60-7, IR68281A x PB-6-12-24-4 and IR 68890A x Basmati Champaran. Amylose content, gel consistency and volume expansion are major cooking quality determinants, 4 hybrids for amylase content, 12 for gel consistency and 7 for volume expansion were identified which showed significant positive standard heterosis. Similar results were also reported by Yolanda and Das (1996). Aroma was not expressed in rice hybrids after cooking of rice kernels in bulk, whereas seeds of F1 plant would be segregated intonon-aromatic and aromatic. Hence it is suggested that every kernel of F1 Plants must be tested for aroma. On the basis of comprehensive study of hybrids, it was concluded that over all three hybrids viz., IR68890A x Khao Hawn, IR68890A x PB-7-16-57-3 and IR 68281A x PB-4-18-57-6 were found to be superior over HUR-36 and PB-1 for most of the yield and quality characters. These hybrids can be utilized commercially after further evaluation.

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STUDIES ON SOIL PHOSPHORUS DYNAMICS IN ORGANIC FARMING IN MAIZE-SUNFLOWER-GREEN GRAM CROPPING SYSTEM

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ABSTRACT

The build up of soil available phosphorus with varied manurial practices was in the descending order with poultry manure, fertilizer, pig manure, neem leaf manure, vermicompost and farm yard manure. Foliar application of *panchagavya* along with any of the organic sources to maize and sunflower crops did not exert any measurable positive influence on available phosphorus in comparison of respective organic sources without the combination of *panchagavya* spray. All the organic manures could result in higher balance of available P than with application of fertilizer to maize and sunflower crops. Irrespective of the manorial sources, use of panchagavya did not exert any noticeable effect on fertility enrichment of the soil.

Key words : Greengram, maize, nutrient balance, *panchagavya*, soil fertility, sunflower .

Organic agriculture is a holistic production management system which promotes and enhances agro-eco system health, including soil biological activity. Organic farming system relies on crop rotations, crop residues, animal manures, legumes, green manures, off-farm wastes and biological pest control. Most of the Indian soils contain less than 0.5 per cent organic carbon and therefore less productive (Veeresh, 2002). In view of the resurgence of interest in alternative agriculture in recent years, organic farming has been considered to be sound and viable option in most of the countries. Complete organic farming movement is a challenge to the scientists, which needs to be looked into more critically. Locally available organic materials such as farm yard manure, poultry manure, pig manure, vermicopmpost, green manures, and crop residues can substitute the inorganic fertilizers to a certain extent to maintain productivity and environmental quality (Chaudhary, 2002). In light of the above, investigations were taken up for two consecutive years, with the objectives working of soil fertility dynamics of the cropping system.

MATERIALS AND METHODS

Field investigations were carried out for two consecutive years (2003-04 and 2004-05) at SV Agricultural College Farm, Tirupati (Southern Agro-Climatic Zone of Andhra Pradesh). In these investigations, the manurial applications were provided to maize and sunflower crops whereas greengram was raised as residual crop during summer in both the years of experimentation. The experiment was laid out in a randomized block design, replicated thrice and the same lay out was followed during the second year of study. There were fourteen treatments comprising of six different sources of nitrogen viz. farm yard manure, vermicompost, neem leaf, poultry manure, pig manure and fertilizer to supply recommended dose of nitrogen on equal nitrogen basis and one treatment of no manuring through any source. All the seven treatments were tried with and without the foliar application of panchagavya, thus making the total treatments to fourteen. The treatments were imposed to earlier maize and sunflower crops only but not for greengram crop. *Panchagavya* is a mixture of cow dung (1kg), cow urine (750 ml), cows milk (500 ml), cows curd (500 ml) and cows ghee (250 ml). In addition, sugarcane juice (750 ml), coconut water (750 ml), pure honey (250 ml) and ripe bananas (250 g) were also added to accelerate the fermentation process. All the parameters of the indigenous mixture are in pure organic origin only. The recommended dose of fertilizers was applied to T_3 and T_4 treatmental plots for maize (120-26-33 kg N-P-K ha^{-1}). Entire quantity of P_2O_5 and K_2O was applied as basal dose. For maize, nitrogen was applied in three equal spits i.e. one third as basal, one third at knee high stage and the remaining one third at tasseling stage. For sunflower, nitrogen was applied in three equal splits i.e. one third as basal, one third at 45 DAS and the remaining one third at 45 DAS. The sources of N, P and K were urea, single super phosphate and muriate of potash, respectively. The fertilizers were applied by placement at 5 cm away and 5 cm below the seed rows.

Plant samples collected for estimation of dry matter were used to estimate the nutrient uptake at periodical intervals during the crop growth period of all the three crops. The oven dried plant samples used for dry matter estimation were chopped and ground into fine powder using Wiley mill and were analyzed for P by adopting the standard procedure Jackson (1973). Available balance of Phosphorus in soil in the cropping system (annual cropping cycle) was computed as per the procedure outlined by Sadanandan and Mahapatra (1973).

The uptake of P at different stages of crop growth of all the three crops was calculated by multiplying the nutrient content with respective dry matter weights and the nutrient uptake was expressed in kg ha^{-1}. With regarding to soil fertility dynamics, immediately after the harvest of each of the three crops during both the annual cropping cycles, soil samples were drawn from individual plots from all the replications and analyzed for available P by following the standard procedure. In all the treatments the organic sources were applied on nitrogen equivalent basis and in turn the P content added through various organic manures is worked out and presented in Table 1.

RESULTS AND DISCUSSION

The pre-experimental and post-harvest fertility of the soil available phosphorus after each of the three crops (maize, sunflower and greengram) was estimated during both the years of study to assess the change in soil fertility status due to cropping system with varied manurial practices with or without the use of panchagavya. Since there was considerable time gap between the termination of first annual cycle and commencement of second annual cycle of the cropping system, pre-experimental sampling of soil was done (prior to incorporation of organic manures to respective plots as per treatments) from all the replicated plots before commencing the second annual cycle of the cropping system, analyzed for all the above mentioned four soil fertility parameters and presented as pre-experimental values (mean of three replications) treatment wise. This was done keeping in view of the possible decomposition as well as mineralization of soil organic matter during the gap period of two annual cycles of cropping system.

Soil available phosphorus

Soil available phosphorus status in the cropping system was found built up at the end of annual cropping cycle compared to the

Table 1. Quantity of P (kg/ha) added through different organic sources

Source	P content	Realized amount of P in maize	Realized amount of P in sunflower
Farm yard manure	0.20	35.29	23.52
Vermicompost	0.50	50.00	33.33
Neem leaf	0.28	67.20	44.80
Poultry manure	2.00	94.48	62.98
Pig manure	0.35	74.99	49.99

pre-experimental level, with the application of organic manures as well as fertilizer either with or without the use of panchagavya (Tables 1 & 2). The build up of soil available phosphorus status with varied manurial practices was in the descending order of poultry manure, fertilizer, pig manure, neem leaf manure, vermicompost and farmyard manure. The former three sources enriched the soil available phosphorus to a greater extent than the latter three sources. Use of panchagavya along with any of the manurial sources did not exert any measurable positive influence on the soil available phosphorus status compared to the respective organic sources tried without the spray of panchagavya. Unmanured plots with or without panchagavya resulted in depletion of the soil available phosphorus. The trend of dynamics of soil available phosphorus in the cropping system with varied manurial practices was found similar in both the annual cropping cycles. However, there was considerable difference in the pre-experimental status of soil available phosphorus between two annual cycles of the cropping system.

Soil available nutrient balance in cropping system

The yearly balance sheet of soil available nitrogen, phosphorus and potassium in the cropping under different manurial practices tried was worked out for both the annual cycles of study, duly considering the quantities of three major nutrients applied to maize and sunflower crops and uptake of the respective nutrients by all the three crops of the cropping system. The change in the soil available nutrient status after completion of each of the annual cycles of the

Table 2. Dynamics of soil available phosphorus (kg/ha) in the cropping system as influenced by varied manurial practices and panchagavya spray 2003-04

Treatments		Pre-experimental	Post-harvest of maize	Post-harvest of sunflower	Post-harvest of greengram
T_1	No manure	17.63	15.24	13.80	12.72
T_2	No manure+ panchagavya	17.63	15.06	13.58	12.70
T_3	Recommended dose of fertilizer	17.63	38.28	31.42	25.15
T_4	Recommended dose of fertilizer + Panchagavya	17.63	37.65	30.76	24.52
T_5	Farm yard manure	17.63	30.42	24.72	18.54
T_6	Farm yard manure + panchagavya	17.63	29.75	24.35	18.28
T_7	Vermicompost	17.63	33.04	27.08	20.60
T_8	Vermicompost + panchagavya	17.63	32.86	26.26	20.26
T_9	Neem leaf	17.63	36.20	29.74	22.82
T_{10}	Neem leaf + panchagavya	17.63	35.93	29.46	22.45
T_{11}	Poultry manure	17.63	41.86	34.50	28.26
T_{12}	Poultry manure + panchagavya	17.63	41.54	33.84	27.84
T_{13}	Pig manure	17.63	36.84	30.28	24.45
T_{14}	Pig manure + panchagavya	17.63	36.40	29.85	23.88

Table 3. Dynamics of soil available phosphorus (kg/ha) in the cropping system as influenced by varied manorial practices and panchagavya spray in 2003-04

Treatments		Pre-experimental	Post-harvest of maize	Post-harvest of sunflower	Post-harvest of greengram
T_1	No manure	13.80	11.85	10.24	8.23
T_2	No manure+ panchagavya	13.80	11.72	10.14	8.18
T_3	Recommended dose of fertilizer	26.75	55.54	47.82	41.40
T_4	Recommended dose of fertilizer + Panchagavya	26.52	55.12	42.74	40.44
T_5	Farm yard manure	20.70	35.94	28.50	22.88
T_6	Farm yard manure + panchagavya	20.42	35.70	28.16	22.43
T_7	Vermicompost	22.50	41.34	40.25	27.92
T_8	Vermicompost + panchagavya	22.38	40.54	38.78	27.64
T_9	Neem leaf	24.25	48.28	44.86	33.63
T_{10}	Neem leaf + panchagavya	24.08	47.65	43.72	33.04
T_{11}	Poultry manure	30.12	63.24	55.34	48.06
T_{12}	Poultry manure + panchagavya	29.96	62.85	54.75	47.04
T_{13}	Pig manure	26.54	53.92	46.52	39.16
T_{14}	Pig manure + panchagavya	26.35	50.98	45.98	38.21

cropping system system was compared with initial status of respective nutrients, to understand the actual dynamics of soil available major nutrients due to raising of different crops under different manurial practices with and without the use of panchagavya.

Soil available phosphorus balance in the cropping system

The balance of available phosphorus in the soil (Tables 5 and 6) under the influence of different manurial practices adopted to first two crops of the cropping system followed similar trend during both the annual cycles, differing only in the magnitude of change of a large extent. The balance of soil available phosphorus was positive with all the manurial practices tried, except in unmanured plots either with or without the use of *panchagavya*, where the balance was negative. Irrespective of manurial sources, use of panchagavya did not exert any noticeable effect in upgrading the soil phosphorus balance. The highest positive balance of soil available phosphorus was associated with poultry manure, which was followed by fertilizer, pig manure, neem leaf manure and vermicompost, while the lowest positive balance was recorded with farm yard manure.

Dynamics of soil fertility in the cropping system, in terms of soil organic carbon, available nitrogen, available phosphorus and available potassium was monitored in all the experimental plots (treatment and replication wise) after harvest of each of the crops and just before the commencement of each of the two annual cropping cycles.

Fertilizer application could just maintain the status of soil organic carbon and available

Table 5. Balance sheet of soil available phosphorus (kg/ha) in maize-sunflower-greengram cropping system 2003-2004

Manurial Practices	Pre-experimental soil available phosphorus	Phosphorus applied				Phosphorus uptake				Post harvest soil avai lable	Change in avail able Phos phorus
		Maize	Sun flower	Green gram	Total to the system	Maize	Sun flower	green gram	Total by the system		
T_1	17.63	0.00	0.00	0.00	0.00	10.80	4.70	2.74	18.24	12.72	-4.91
T_2	17.63	0.00	0.00	0.00	0.00	10.86	4.75	2.82	18.43	12.70	-4.93
T_3	17.63	25.80	21.50	0.00	47.30	19.40	8.85	3.68	31.93	25.15	+7.52
T_4	17.63	25.80	21.50	0.00	47.30	19.46	9.02	3.72	32.20	24.52	+6.89
T_5	17.63	35.29	23.52	0.00	58.81	19.56	9.16	5.22	33.94	18.54	+0.91
T_6	17.63	35.29	23.52	0.00	58.81	19.62	9.28	5.25	34.15	18.28	+0.65
T_7	17.63	50.00	33.33	0.00	83.33	20.92	10.46	5.278	36.66	20.60	+2.97
T_8	17.63	50.00	33.33	0.00	83.33	20.95	10.62	5.28	36.85	20.26	+2.63
T_9	17.63	62.22	41.47	0.00	103.69	21.06	10.76	7.02	38.84	22.82	+5.19
T_{10}	17.63	62.22	41.47	0.00	103.69	21.14	10.82	7.08	39.04	22.45	+4.82
T_{11}	17.63	94.48	62.98	0.00	157.46	23.86	13.28	8.02	45.16	28.26	+10.63
T_{12}	17.63	94.48	62.98	0.00	157.46	24.00	13.40	8.10	45.50	27.84	+10.21
T_{13}	17.63	74.99	49.99	0.00	124.98	22.48	12.02	7.52	42.02	24.45	+6.82
T_{14}	17.63	74.99	49.99	0.00	124.98	22.54	12.10	7.56	42.20	23.88	+6.25

Table 5. Balance sheet of soil available phosphorus (kg/ha) in maize-sunflower-greengram cropping system 2003-2004

Man-urial Prac-tices	Pre-experi-mental soil available phos-phorus	Phosphorus applied				Phosphorus uptake				Post harvest soil avai lable	Change in avail able Phos phorus
		Maize	Sun flower	Green gram	Total to the system	Maize	Sun flower	green gram	Total by the system		
T_1	13.80	0.00	0.00	0.00	0.00	11.30	5.32	3.64	20.26	8.23	-5.57
T_2	13.80	0.00	0.00	0.00	0.00	11.54	5.38	3.82	20.74	8.18	-5.62
T_3	26.75	25.80	21.50	0.00	47.30	20.08	9.12	4.86	34.06	41.40	+14.65
T_4	26.52	25.80	21.50	0.00	47.30	20.24	9.28	4.98	34.50	40.44	+13.92
T_5	20.70	35.29	23.52	0.00	58.81	20.42	9.42	6.52	36.36	22.88	+2.18
T_6	20.42	35.29	23.52	0.00	58.81	20.48	9.58	6.54	36.60	22.43	+2.01
T_7	22.50	50.00	33.33	0.0	83.33	21.85	10.76	6.58	39.19	27.92	+5.42
T_8	22.38	50.00	33.33	0.00	83.33	22.06	10.94	6.58	39.58	27.64	+5.26
T_9	24.25	62.22	41.47	0.00	103.69	22.18	11.04	7.78	41.00	33.63	+9.38
T_{10}	24.08	62.22	41.47	0.00	103.69	22.20	11.16	7.80	41.16	33.04	+8.96
T_{11}	30.12	94.48	62.98	0.00	157.46	25.60	13.96	8.83	48.39	48.06	+17.94
T_{12}	29.96	94.48	62.98	0.00	157.46	25.70	14.10	8.90	48.70	47.04	+17.08
T_{13}	26.54	74.99	49.99	0.00	124.98	24.00	12.40	8.30	44.70	39.16	+12.62
T_{14}	26.35	74.99	49.99	0.00	124.98	24.10	12.70	8.32	45.12	38.21	+11.86

nitrogen status in the cropping system, with neither improving nor declining at the end of the annual cropping cycles. While they were found gradually built up compared to the pre-experimental level, with all the three crops raised with the application or organic manures. Among the organic sources tried, neem leaf manure, vermicompost and farmyard manure added more organic carbon to the soil compared to pig manure and poultry manure, while neem leaf manure, poultry manure and vermicompost replenished more available nitrogen to the soil than with pig manure and farmyard manure. Further, the mineralization of organic manures and release pattern of nitrogen into the soil solution differs a large and accordingly, the final balances of soil organic carbon and available nitrogen would reflect source-wise. Nevertheless, organics did build up the organic carbon content as well as nutrients there by indicating the sustenance of soil productivity.

Soil available phosphorus status in the cropping system was found built up at the end of annual cropping cycle compared to the pre-experimental level, with the application of organic manures as well as fertilizer. The build up of soil available phosphorus status with varied manurial practices was in the descending order of poultry manure, fertilizer, pig manure, neem leaf manure, vernicompost and farmyard manure, while the build up of soil available potassium status with varied manurial practices was in the descending order of vermicompost, pig manure, neem leaf manure, farmyard manure, poultry manure and fertilizer. The P and K content of different organic sources. Soil available P was found depleted at the end of two year cropping cycles dye to non-manuring to any of the crops in the cropping.

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EFFECT OF PLANTING DATES AND SPACING ON GROWTH AND YIELD OF BROCCOLI (*BRASSICA OLERACEA VAR.* ITALICA L.)

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ABSTRACT

To see the response of date of planting and spacing on growth and yield of Broccoli var. Fiesta, the present study was carried out at Vegetable Research Farm, Kalyanpur, Kanpur during rab 2003-04 and 2004-05. Three date of planting i.e. (15 Oct., 30 Oct., and 15 November) and three plant spacing (45 cm x 30 cm, 45 cm x 45 cm and 45 cm x 60 cm) were applied in combination in Randomized Block Design with three replication. On the basis of study, it has been concluded that significantly maximum plant height and of number leaves/plant, early curd initiation and early curd maturity were recorded when broccoli was transplanted earliest at 15 October to 30 October. The maximum length and width of curd and yield of curd (145.63 q/ha and 160.45 q/ha) were also noted under 15 October planting during both the year. Increase in spacing (45 x 60 cm) significantly increased the plant height, number of leaves/ plant, reduced the days taken to curd initiation, increased the length and width of curd and gave significantly higher curd yield (149.43 and 165.32 q/ha) than 45 x 30 cm and 45 x 45 cm spacing. Hence, early planting (15 October to 30 October) of broccoli with wider spacing (45 x 60 cm) proved superiority over later planting (15 November) and narrow spacing (45 x 30 cm and 45 x 45 cm).

Key words : Broccoli, nitrogen, spacing, yield.

In recent past, broccoli has emerged and important vegetable among commonly grown Brassica vegetables in India. Embedded with sulphur containing phytochemicals like glucosinolate and *S. vetholeysteie*, broccoli possesses strong anticarinogenic activity (Pandey and Rai, 2006). This vegetable crop is grown as a winter crop in northern parts of India. It is nutritious among cole crops being rich in vitamins and sulphoraphane which is associated with reducing the risk of cancer (Kalia, 1995). It is used for salad, curries, fried, boiled or for cooking with other vegetables.

Broccoli is a new crop in India. Efforts have not been done so far regarding standardization of package of practices of this crop. Some work has been done only in few research institutes of India. Times of planting is one of the important factor which affect yield of broccoli. Not much work has been carried out on this aspect which necessitates the planning of experiment by including different dates of planting as one of the factor. Another important factor which has a crucial impact on yield and quality of broccoli is row spacing i.e. use of optimum space between rows and plants play an important role in crop production. Therefore, the present study was carried out to determine the optimum planting date and spacing for obtaining better growth, and yield of broccoli.

MATERIALS AND METHODS

The present experiment was carried out during winter season of 2003-04 to 2004-05 at Vegetable Research Farm of C.S. Azad University of Agriculture & Technology, Kanpur to study the effect of date of planting and spacing on growth and productivity of broccoli. The experimental site is located in the belt of genetic plan in central U.P. The soil of experimental field was sandy loam in texture having pH 7.4, organic carbon 0.44%, available P_2O_5-20.30 Kg/ha and available K_2O-126 Kg/ha. All possible combinations of three dates of planting (15, 30 October and 15 November) and three plant

Table 1. Effect of planting dates and spacing on growth parameters of broccoli

Treatment	Plant height (cm)				No. of leaves /plant				Curd initiation	
	2003-04		2004-05		2003-04		2004-05		2003-04	2004-05
	45 DAT	At maturity	45 DAT	At maturity	45 DAT	At maturity	45 DAT	At Maturity	Days taken	Days taken
Planting Dates										
15 Oct.	16.9	30.1	15.9	28.3	10.5	14.6	12.0	14.2	56.1	58.0
30 Oct.	16.0	29.9	15.6	27.9	10.2	13.3	11.2	13.9	57.1	58.8
15 Nov.	15.2	25.4	14.8	24.1	9.75	13.5	10.6	12.8	59.8	60.3
C.D.at 5%	0.35	0.92	.052	0.72	0.46	1.02	0.58	0.76	1.42	1.04
Spacing										
45cm x 30cm	14.9	27.1	14.1	25.1	9.90	13.1	9.10	14.8	60.0	60.1
45cm x 45cm	15.2	28.6	14.8	25.9	10.55	14.5	9.60	15.1	60.7	59.3
45cm x 60cm	16.7	29.9	15.2	27.6	11.86	15.9	10.1	15.6	57.7	58.0
C.D. at 5 %	0.25	0.74	0.28	0.45	0.38	0.82	0.32	0.49	0.63	0.77

Table 2. Effect of planting dates and spacing on yield parameters of broccoli

Treatment	Curd maturity		Curd				Yield	
	2003-04	2004-05	2003-04		2004-05		2003-04	2004-05
	Days taken	Days taken	Length (cm)	width (cm)	Length (cm)	width (cm)	q/ha	q/ha
Planting Dates								
15 Oct.	65.2	60.6	10.3	12.1	10.80	12.5	145.6	160.4
30 Oct.	66.4	62.0	9.9	11.4	10.05	11.9	139.9	154.3
15 Nov.	67.7	64.2	8.4	10.3	9.30	9.60	130.3	139.4
C.D.at 5%	1.05	1.14	1.17	0.76	1.06	0.72	8.04	6.52
Spacing								
45cm x 30cm	66.6	64.8	8.20	10.5	9.05	10.8	135.8	143.0
45cm x 45cm	65.7	63.1	9.25	11.5	9.85	11.8	142.6	154.8
45cm x 60cm	64.2	62.2	10.9	12.7	11.1	12.6	149.4	165.3
C.D. at 5 %	0.82	0.83	0.92	1.02	0.74	0.99	5.89	10.08

spacing (45cm x 30 cm, 45 cm x 45cm and 45 cm x 60 cm), were allocated in a randomized block design and replicated thrice. The observation with regards to the growth and yield characters were recorded at periodic intervals to assess the response of treatments on growth and yield of broccoli. The data were analyzed statistically using analysis of variance technique.

RESULTS AND DISCUSSION

The observation (Table 1) clearly reveal that the growth parameters varied significantly due to treatment factors. The maximum plant height (16.9 cm, 15.9 cm at 45 DAT and 30.1 cm, 28.3 cm at maturity time) and no. of leaves/plant (10.5, 12.0 at 45 DAT and 14.62, at maturity) were recorded under 15 October planting. The planting dates of 15 October and 30 October showed comparable response but significantly superior over15 November planting. The early curd initiation and curd maturity also differed significantly with each other. The 15 October planting gave earliest curd initiation (56.1 and 58.0 DAT) and curd maturity (65.2 and 60.6 DAT) in comparison to 30 October to 15 November planting. The maximum length (10.3 and 10.8 cm) and width (12.1 cm and 12.5 cm) of curd and yield of curd (145.6 and 160.4 q/ha) were also recorded under (130.3 and 139.4 q/ha) was recorded under 15 November planting during both the years. Earlier planting (15 October) enhanced the curd yield of broccoli over later planting (15 November) by a margine of 11.53 % and 15.10% during first and second year of investigation, respectively. Delayed planting reduced curd formation which might be due to the fluctuation in the temperature during growing season. Similar result have been reported by Sharma et al. (1994) in cauliflower. Tables 1 and 2 clearly indicated that the growth and yield parameter were also affected significantly with different spacings. The transplanting of seedling at 45 cm x 60 cm significantly increased the plant height at 45 DAT and at maturity (16.70 and 29.95 cm in first year and 15.25 and 27.62 cm in second year), maximum number of leaves per plant (11.86 and 15.90 in 1 year and 10.15 and 15.60 in 2 year) and reduced the days taken to curd initiation during both the years of investigation. The present findings are in conformity with the findings of Subhan (1988) and Kanthaswamy et al. (2000). Increase in spacing significantly increased the length and width of curd in both the years. The maximum curd length (10.9 cm and 11.1 cm) and width (12.7 cm and 12.6 cm) were recorded under 45 cm x 60 cm spacing in first and second year, respectively. The above findings are in conformity with the findings of Subhan (1988) and Brock. The curd yield was also differed and affected significantly by spacing. The plant spaced at 45 cm x 60 cm gave significantly higher curd yield (149.4 and 165.4 q/ha) and it was markedly more than 45 cm x 30 cm and 45 cm x 45 cm spacing by a margin of 10% and 4.92% respectively. Mullins and straw (1992), Brock (1996), Kanthaswamy (2000) also agreed with the present findings

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EFFECT OF VARIETIES AND NITROGEN LEVELS ON GROWTH AND YIELD OF KODO MILLET (*PASPALUM SCROBICULATUM* L.) UNDER RAINFED CONDITIONS

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Abstract

Kodo millet (*Paspalum scrobiculatum* L.) is an important millet grown under rainfed conditions in India. A very low productivity of kodo millet necessitates the development of important production technologies for this crop. Hence a field experiment was conducted during rainy season for four years (2006-09) at S.G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh to identify a suitable variety and nitrogen dose for kodo millet. Among various varieties, GPUK 3 grew significantly taller with higher number tillers/plant, raceme/plant, and raceme length than the remaining varieties. Grain (q/ha) and straw yields obtained from this variety were the highest. Increasing levels of nitrogen from 0 to 40 kg/ha significantly increased grain yield.

Key words : Kodo millet, nitrogen, *Paspalum*.

Kodo millet (*Paspalum scrobiculatum*) is one of the important millets grown in India. However, cultivation of its traditional varieties in rainfed marginal lands without use of any fertilizers results in the poor yield. To exploit the high yield potential of the crop quantity of nitrogenous fertilizers with split application directly involves in enhancing crop productivity (Satyanarayanan *et al.*, 1985). This experiment was carried out to study the influence of different varieties and nitrogen levels on growth and yield of kodo millet under rainfed conditions.

Materials and Methods

The field experiment was conducted during the rainy seasons of 2006, 2007, 2008 and 2009 at S.G. College of Agriculture and Research Station, Jagdalpur. The experiment consisted of four varieties (RK 98, ICK 1042, RBK 155 and GPUK 3) and three nitrogen levels (0, 20 and 40 kg N per ha). Nitrogen was given in two equal splits i.e. basal and at 35 days after sowing, and P_2O_5 and K_2O were given as basal at the rate of 20 per ha each. The treatments were tested in factorial randomized block design with three replications. The soil of experimental field was light in texture (pH 7.3) with low organic carbon (0.30%) and available nitrogen (10 kg/ha), and high available potassium (443 kg/ha). Sowing was done by opening furrows 2 cm apart during last of June every year.

Results and Discussion

Effect of varieties

Variety GPUK 3 produced significantly taller plants with higher number of tillers per hill, receme per hill and longer receme than other varieties. But, test weight did not differ significantly among varieties (Table 1). Better growth and yield attributes of GPUK 3 were reflected in higher yield of this variety (Table 2) mainly due to higher and well distributed rainfall during growth and development of crop in 2006 and 2009. Rainfall during early growth period was generally low; excess rainfall received during mid September which coincided the flowering stage, and led to inundation and subsequently lodging. This affected largely the grain formation resulting in lower yields of varieties RK 98, ICK 1042 and RBK 155 (Rao *et al.*,1991).

Effect of nitrogen levels

Increasing levels of nitrogen significantly increased the plant height, number of tillers/hill, number of recemes/plant and receme length, (Table 2). Application of 20 and 40 kg N/ha being at par, significantly improved all these attributes compared to no application of nitrogen (control). Gutam *et al.* (1982) also reported the favourable effects of nitrogen on growth of crop. The grain yield increased consistently with increasing levels of nitrogen from 0 to 40 kg/ha (Table 2). However, significant increases in yields were observed only up to 40 kg/ha in all the study. This result confirms to the findings of Rao et al. (1986).

Interaction effect

The interaction was significant between nitrogen and varieties. Although all the varieties respond positively to nitrogen application but GPUK 3 performed better under all the levels of nitrogen in relation to attributes and yield of

Table 1. Effect of varieties and nitrogen levels on growth and yield attributes of kodo millet (mean of 4 years)

Treatments	Plant Height (cm)	Tillers/ hill	Racemes/ tiller	Raceme length (cm)	Test weight (g)
Varieties					
RK 98	53.1	2.8	3.2	5.8	6.6
ICK 1042	47.0	2.7	3.1	5.5	6.1
RBK 155	49.2	2.5	2.7	5.8	6.0
GPUK 3	56.3	3.1	3.3	5.9	6.6
SEm ±	1.1	0.1	0.1	0.1	0.1
CD (P=0.05)	3.3	0.3	0.3	0.4	NS
Nitrogen levels (N kg/ha)					
0	43.9	2.8	3.0	5.5	6.1
20	52.9	2.6	2.9	5.8	6.2
40	55.9	2.9	3.3	6.1	6.7
SEm ±	0.9	0.1	0.1	0.1	0.1
CD (P=0.05)	3.1	0.3	0.3	0.4	NS

Table 2. Effect of varieties and nitrogen levels on grain and straw yield of kodo millet

	Grain yield (q/ha)				Straw yield (q/ha)			
Treatments	2006	2007	2008	2009	2006	2007	2008	2009
Varieties								
RK 98	17.1	11.6	14.9	17.0	64.2	50.8	34.7	55.9
ICK 1042	16.4	10.8	11.4	16.2	53.8	49.1	30.2	49.7
RBK 155	10.6	9.6	10.3	9.8	49.3	33.3	25.0	54.6
GPUK 3	19.1	12.9	15.4	19.1	76.2	53.5	36.8	68.3
SEm ±	0.6	0.5	0.2	0.7	4.1	0.9	0.8	4.2
CD	1.9	1.3	0.5	2.0	12.0	2.6	2.2	12.5
Nitrogen levels (N kg/ha)								
0	9.8	5.7	8.2	9.9	49.6	40.1	38.9	47.1
20	13.3	12.4	13.8	13.1	59.7	48.4	41.8	58.9
40	16.8	15.6	16.9	16.1	73.3	51.4	44.4	72.3
SEm ±	1.2	1.1	1.0	0.9	4.6	1.0	1.5	4.5
CD	3.5	3.2	3.1	2.1	13.6	3.0	3.6	13.4

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INFLUENCE OF SEED RATE AND WEED MANAGEMENT ON PRODUCTIVITY AND ECONOMICS OF WHEAT (*TRITICUM AESTIVUM*)

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Abstract

A field experiment was conducted during the winter (*rabi*) seasons of 2005-06 and 2006-07 at Varanasi, Uttar Pradesh, to assess the effect of four seed rates viz. 75, 100, 125 and 150 kg/ha on wheat (*Triticum aestivum* L. emend. Fiori & Paol.) productivity and to evolve efficient weed control method involving mechanical weeding at 15 and 30 days after sowing (DAS), rice straw mulch (2 tones/ha), neem oil spray (3%) at 30 DAS, sulfosulfuron (25 g/ha) at 30 DAS and weedy check. Increasing seed rates from 75 to 150 kg/ha significantly decreased dry weight of weeds in wheat. On an average, use of 125 kg/ha seed rate, being on a par with 100 kg seed/ha, gave significantly 20 and 26% higher grain yield than 75 and 150 kg seeds/ha, respectively. Maximum net return, benefit: cost ratio and NPK uptake by wheat was obtained with 125 kg seed/ha. Among weed control methods, mechanical weeding twice at 15 and 30 DAS proved the most effective treatment in reducing weeds dry weight which was on a par with sulfosulfuron 25 g/ha, and gave significantly higher grain yield and N, P and K uptake by wheat than weedy check. Mechanical weeding at 15 and 30 DAS resulted in the highest (35.4-45.1 per cent) increase in grain yield over weedy check, but highest net return (Rs. 27, 620-32,224/ha) and benefit: cost ratio (1.79-1.85) was obtained with sulfosulfuron (25 g/ha) application.

Key words : Wheat, seed rate, weed control method, grain yield, economics.

Weeds are one of the major factors in reducing the wheat productivity by 30-50% (Brar *et al.*, 2003) and therefore, need immediate attention. Weeds in wheat are generally controlled with manual and cultural manipulations. Nowadays, herbicide use for weed control in wheat is becoming increasingly popular. Indiscriminate use of herbicides in wheat has, however, resulted in resistance problem (Walia *et al.*, 1997) and herbicides residues in environment. Reducing herbicide use in wheat is a prime concern today. Efforts are towards search for new technologies like use of natural herbicides and conservation tillage, and cultural practices such as higher seed rate, mechanical weeding, mulching, smother crops etc. as a component of integrated weed management programme that will play a significant role in weed suppression, besides being economical and eco-friendly. Therefore, there is need to develop a holistic weed management strategy, which is sustainable in terms of enhanced productivity without eroding the resource. In wheat, variable seed rate used in different parts of India ranges from 50 to 150 kg/ha depending on varying seed size, time and method of sowing. A high seed rate is required to secure weed growth. Weed density and dry matter are supposed to be suppressed substantially through increasing plant populations (Zimdahl, 1999). Thus, variation in seed rate and weed control method interact to influence growth and yield of wheat. This information is important to know the appropriate and economically viable method of weed control in wheat grown under different seed rates.

Materials and Methods

A field experiment was conducted during the winter (*rabi*) seasons of 2005-06 and 2006-07 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25° 18' N, 83° 03' E and 129 m above mean sea level), Uttar Pradesh under lowland irrigated conditions. The soil of experimental site was sandy clay loam, slightly alkaline (pH 7.6) in reaction and moderately fertile being low in organic carbon (0.36%) and available nitrogen (185.2 kg N/ha) and medium in available phosphorus (19.7 kg P/ha), and potassium (208.5 kg K/ha). The experiment had 20 treatments, comprising combination of four seed rates (75, 100, 125 and 150 kg/ha) and five weed control methods (mechanical weeding twice at 15 and 30 days after sowing (DAS), rice straw mulch (2 tones/ha), neem oil spray (3%) at 30 DAS, sulfosulfuron (25 g/ha) at 30 DAS and weedy check). These were evaluated under split plot design, in plots of size 6.0 m x 3.0 m allocating seed rates to main plot and weed control methods to sub-plots with three replications. Herbicide was sprayed using manually operated knapsack sprayer fitted with flat-fan nozzle delivering a spray volume of 600 liters water/ ha. Wheat 'HUW-234' was sown on 19 December, 2005 and 2 December, 2006 at row spacing of 23 cm and harvested of practices on 18 and 15 April in 2006 and 2007, respectively adopting all recommended package of practices except the treatments. Recommended dose of fertilizers (120 kg N + 26.2 kg P and 50 kg K/ha) was applied through urea, diammonium phosphate and muriate of potash, respectively. Full dose of P and K, and half the dose of N were applied as basal at the time of sowing and remaining N in 21 equal splits; at tillering and panicle initiation stages of the crop. Observation on weeds were recorded at 60 DAS with the help of quadrate (50 cm x 50 cm) from four places in each plot and subjected to square root transformation before statistical analysis. The treatments by year interactions were not significant in weed indices and so the data for both the years were pooled, and however the data of growth yield and NPK uptake were significant and so the treatments were statistically analyzed yearly by the analysis of variance technique for split-plot design. The NPK uptake of weeds at 60 DAS and grain and straw of wheat were estimated as per standard procedure. Comparative economics of various treatments were calculated on the basis of prevailing market price of inputs used and the output obtained under each treatment.

RESULTS AND DISCUSSION

Weed growth

The predominant weeds observed in the experimental field were *Rumex* (34.3%), *Anagallis arvensis* L. (21.9%), *Chenopodium album* L. (16.2%) *Phalaris minor* Retz. (19.8%) and *Cyperus rotundus* L. (7.2%).

Increasing rates of seed from 75 to 150 kg/ ha decreased in weed population of broad leaved weeds, grasses and sedges and dry weight of weeds (Table 1). Increased plant density per unit area achieved by higher seed rate probably caused smothering of weeds and resulted into reduced their dry weight. Blackshaw *et al.* (2005) also reported that higher crop seed rates had a consistently positive effect on reducing weed growth. Seed rate of 150 kg/ ha reduced 7.4, 15.0 and 22.9% dry weight of seeds compared to 125 kg, 100 kg and 75 kg seeds/ha respectively, because the unknown space was reduced to minimum which did not provide enough sunlight and space for all weed seeds to germinate and checked initial growth of germinated weeds. Consequently, the highest seed weed control efficiency (59.9%) under 150 kg/ha and lowest (50.7%) under 75 kg/ha were recorded.

Weed control methods significantly reduced the weed population of broad leaved weeds, grasses and sedges, and dry weight of weeds and increased weed control efficiency compared with weedy check (Table 1). Sulfosufuron at 25 g/ha proved the most effective treatment against broad leaved weeds and recorded significantly lower population of this weed than other weed control methods. Mechanical weeding reduced the weeds population of grasses and sedges, but the other weed control methods proved less efficient in controlling these weeds. Mechanical weeding recorded significantly lower dry weight of seeds than sulfosufuron, rice straw mulch and neem oil treatment. Further, dry weight of seeds was also significantly lower with sulfosufuron treatment than other weed control methods, was due to effective control of broad leaved weeds which constituted the major proportion of weed

Table 1. Effect of seed rate and weed control method on weeds population, weeds dry weight and weed control efficiency in wheat (Pooled data of 2005-06 and 2006-07)

Treatment	Weeds population (no/m^2)			
	Broad leaved	Grasses	Sedges	Weeds dry weight (g/m^2)
Seed rate (kg/ha)				
75 kg/ha	5.47 (29.4)	4.01 (15.5)	2.61 (6.3)	6.2 (37.9)
100 kg/ha	5.27 (27.3)	3.66 (12.9)	2.49 (5.7)	6.0 (35.5)
125 kg/ha	5.13 (253.8)	3.27 (10.2)	2.30 (4.8)	5.8 (33.1)
150 kg/ha	4.85 (23.0)	3.03 (8.7)	2.07 (3.8)	5.6 (30.9)
CD (P=0.05)	0.29	0.29	0.26	0.38
Weed control method				
Mechanical weeding at 15 and 30 DAS	4.66 (21.9)	2.72 (6.9)	1.49 (1.7)	4.4 (18.9)
Rice straw mulch (2 t/ha)	5.25 (26.9)	2.72 (6.9)	1.49 (1.7)	4.4 (18.9)
Neem oil spray (3%) at 30 DAS	5.48 (29.5)	4.12 (16.5)	2.49 (5.7)	5.9 (34.3)
Sulfosulfuron (25 g/ha) at 30 DAS	4.26 (17.6)	2.97 (8.3)	1.89 (3.1)	4.7 (21.6)
Weedy check	6.27 (38.8)	4.25 (17.6)	3.49 (11.7)	8.8 (72.1)
CD (P=0.05)	0.20	0.20	0.19	0.30

population recorded in the experimental plots. Therefore, the highest weed control efficiency (75.5%) was recorded under mechanical weeding followed sulfosufuron, rice straw mulch and neem oil treatment, respectively. The lowest dry weight of weeds under mechanical weeding was due to proper control of weeds up to 30 DAS. Thereafter the emergence of new flushes could not attain full growth under the shade of crop plants.

Growth and yield

The effect of seed rates on growth and yield attributes *viz.* plant height, effective tillers/m row length, grains/spike and 1000-grain weight did not vary significantly in the first year but was significant in the second year (Table 2). Seed rate of 125 gm/ha recorded maximum plant height (99.8 cm) which was on a par with 100 and 150 kg/ha, respectively but was significantly superior to 75 kg seed/ha. Further, effective tillers/m row length was increases significantly with increasing speed rate up to 125 kg/ha. However, grains/spike and 100-grain weight were decreased with increase in seed rates from 75 to 150 kg/ha. Jeffery *et al.* (1991) observed increasing seed rate from 67 to 101 kg/ha increased winter wheat yield and its attributes over a range of weed infestation. More grains/spike at lower seed rate was due to less competition among the plants for light, moisture and nutrients compared with those at higher seed rate. The mutual competition among plants at higher seed rate decreased grains/spike and 1000-grain weight.

Variation in seed rates significantly influenced the grain and straw yield of wheat and recorded the highest value (3.84 and 3.96 t/ha wheat grain yield, and 5.46 and 5.59 t/ha wheat straw yield in the first and second years, respectively) at 125 kg seed/ha which wason par with 100 kg seed/ha, but was significantly superior to rest of speed rates (Table 2). On an average, seed rate of 125 kg/ha gave 4.0% more than wheat grain yield than 100 kg seed/ha (3.75 t/ha), which in turn recorded 20.0% and 26.0% more grain yield than 75 and 150 kg seed/ha, respectively. Naik *et al.* (1991) also reported that seed rate of 125 kg/ha produce higher grain and straw yields than other lower seed rates. Selection of appropriate plant density for higher productivity depends mainly on tillering and lodging. Therefore, higher grain and straw yields at 125 kg seed/ha may be ascribed to increase in crop dry biomass and number of effective tillers/m. High plant density beyond optimum leads to mutual competition among plants at 150 kg seed/ha decreased yield of wheat.

Weed control methods significantly influenced all growth and yield attributes of wheat in the second year only (Table 2). Mechanical weeding twice, being on par with sulfosulfuron 25 g/ha and rice straw mulch, recorded significantly higher plant height, grain/spike and 1000-grain weight compared to neem oil treated plots except in grains/spike. The highest number of effective tillers was recorded in mechanical weeding which was significantly higher than other weed control methods. Pandey and Verma (2002) reported significant increase in growth and yield attributes of wheat due to herbicide application and manual hoeing. The post-emergence application of sulfosulfuron at 25 g/ha did not control all the weeds effectively and might have caused phytoxocity to crop, leading to lesser growth and yield attributes compared with mechanical weeding twice. However, no phytoxic effect of neem oil spraying on crop was observed but crop colour changed to dark green. As such, neem oil, a natural herbicide appears to be selective. Due to stiff competition from weeds the growth and yield attributes were recorded the least in the weedy check plots.

Weed control methods resulted in significant increase in grain and straw yields of wheat as compared with weedy check (Table 2). Among weed control methods, mechanical weeding at 15 and 30 DAS resulted in significantly higher grain yield than rest of weed control methods. Hence, the highest increase in grain yield up to 35.4 and 45.1% was recorded under mechanical weeding followed by sulfosulfuron (33.0 and 43.8%), rice straw mulch (19.3 and 27.4%) and neem oil (12.3 and 5.6%) treatments in the first and second years, respectively over the weedy check. Similar trend was noted in straw yield also under each treatment. The higher wheat grain and straw yields under weed control treatments may be due to marked decrease in population and dry weight of weeds and thereby better crop growth and yield attributes.

Nutrient uptake by crop and weeds

The uptake of NPK in wheat grain and straw increased with increase in seed rates from 75 to 125 kg/ha but decreased thereafter (Table 4). The highest uptake of these nutrients in 125 kg seed/ha might be attributed to greater production of crop biomass. In general, the uptake of these nutrients related to the yield of crop. Weed control methods significantly increased NPK uptake by grain and straw of wheat than weedy check (Table 4). The best weed control methods viz. mechanical weeding twice at 15 and 30 DAS and sulfosulfuron 25 g/ha being on par recorded significantly higher NPK uptake by wheat compared to rest of weed control treatments. The better nutrients uptake by the crop was associated with its better better growth and development, resulting in higher yield.

Use of higher seed rates effectively decreased uptake of NPK by weeds and significantly the lowest uptake of NPK by weeds was recorded with 150 kg seed/ha compared with the highest NPK uptake by weeds at 75 kg seed/ha (Table 4). The lowest uptake of these nutrients by weeds was associated with lowest dry weight of weeds under higher seed rate. Significant improvement in the uptake of NPK by weeds was recorded due to various weed control methods compared with that of weedy check (Table 4). Among weed control methods, application of sulfosulfuron 25 g/ha significantly minimized the uptake of NPK by weeds, which was found on a par with mechanical weeding twice and significantly superour to other weed control methods. Pandey et al. (2001) reported reduction in NPK uptake by weeds under sulfosulfuron and mechanical weeding was due to less production of weed dry weight these treatments.

Table 2. Effect of seed rate and weed control method on growth and yields of wheat

Treatment	Plant height (cm)		Effective tillers/m m		Grains/spike		1000 grain weight (g)		grain yield (t/ha)		Straw yield (t/ha)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Seed rate (kg/ha)												
75 kg/ha	81.1	88.7	45.4	54.9	39.7	38.1	36.9	38.7	3.22	3.28	5.07	5.08
100 kg/ha	81.9	98.7	49.3	58.6	39.7	37.5	36.6	37.9	3.69	3.81	5.35	5.51
125 kg/ha	83.2	99.8	51.0	63.3	39.2	35.6	35.4	36.6	3.84	3.96	5.46	5.59
150 kg/ha	82.5	97.1	52.1	66.3	36.8	34.5	34.9	34.7	2.92	3.27	4.71	4.89
CD (P=0.05)	NS	6.7	NS	4.2	NS	2.4	NS	2.5	0.30	0.26	0.38	0.37
Weed control method												
Mechanical Weeding at 15 and 30 DAS	84.5	103.8	52.3	70.2	40.2	37.8	37.6	38.6	3.86	4.18	5.40	5.78
Rice straw mulch (2 tones/ha)	83.3	101.5	51.2	63.8	39.4	36.6	36.8	37.2	3.40	3.67	5.10	5.48
Neem oil spray (3%) at 30 DAS	82.7	83.3	49.1	51.3	38.1	35.8	37.5	35.8	3.20	3.04	5.01	4.71
Sulfosulfuron (25 g/ha) at 30 DAS	84.1	102.4	51.7	65.9	39.9	37.3	37.4	37.6	3.79	4.14	5.40	5.75
Weedy check	76.3	89.4	43.0	52.9	36.6	34.6	32.5	35.6	2.85	2.88	4.80	4.63
CD (P=0.05)	NS	5.4	NS	3.5	NS	2.1	NS	2.1	0.24	0.22	0.35	0.31

Table 3. Effect of seed rate and weed control method of economics of wheat

Treatments	Cost of cultivation (x 103 Rs./ha)		Net returns (x 103 Rs./ha)		Benefit : cost ratio	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Seed rate (kg/ha)						
75 kg/ha	15.0	16.8	22.6	23.7	1.51	1.41
100 kg/ha	15.2	17.1	26.8	29.0	1.76	1.69
125 kg/ha	15.5	17.4	28.1	30.2	1.81	1.73
150 kg/ha	15.8	17.7	18.5	22.4	1.17	1.26
Weed control method						
Mechanical weeding at	17.1	19.6	26.6	30.4	-	-
15 and 30 DAS					1.55	1.50
Rice straw mulch	16.8	18.7	22.4	26.2		
(2 tonnes/ha)					1.33	1.39
Neem oil spray	14.6	16.5	22.8	21.1		
(3%) at 30 DAS					1.56	1.28
Sulfosulfuron	15.4	17.3	27.6	32.2		
(25 g/ha) at 30 DAS					1.79	1.85
Weedy check	14.1	16.0	19.7	20.0		
					1.39	1.25

Price of wheat grain: Rs. 8.5/kg in both the years; Straw: Rs. 2.0 in 2005-06 and 2.5 kg/ha in 2006-07; Sulfosulfuron: Rs. 970/ha; Mechanical weeding: Rs. 1,500/ha in 2005-06 and Rs. 1,800/ha in 2006-07 for 15 man days.

Economics

Net return and benefit: cost ratio increased with increasing seed rates up to 125 kg/ha which recorded the highest net return (Rs. 28,060/ha in 2005-06 and Rs. 30,249/ha in 2006-07) and benefit: cost ratio (1.80 in 2005-06 and 1.73 in 2006-07) Further, increasing in seed rates from 125 to 150 kg/ha caused reduction in net return and benefit: cost ratio owing to higher cost of seed and lower yield (Table 3).

All weed control methods gave higher net return and benefit: cost ratio than weedy check (Table 3). Lower grain and straw yields due to severe crop-weed competition throughout the crop season in weedy check plots could be the reason for decrease in net return. However, post-emergence application of sulfosulfuron at 25 g/ha was found more remunerative, as it fetched the highest net return (Rs./ha 27,620 in 2005-06 and Rs./ha 32,224 in 2005-06) and benefit: cost ratio (1.79 in 2005-06 and 1.85 in 2006-07) compared with other weed control methods. The higher cost of weed control is the reason for lower value of net return (Rs./ha 26,645 in 2005-06 and Rs./ha 30,369 and Rs./ha 30,369 in 2006-07) under mechanical weeding treatment in spite of the highest grain and straw yields. It can, therefore, be concluded that under existing agro-climatic conditions, sowing at 125 kg seed/ha with post-emergence application of sulfosulfuron at 25 g/ha is the most remunerative and efficient weed control method for achieving high yield in wheat.

Table 4. Effect of seed rate and weed control method on NPK uptake by wheat and weeds

Treatments	Nitrogen uptake (kg/ha)				Phosphorus uptake (kg/ha)				Potassium uptake (kg/ha)			
	Wheat		Weeds		Wheat		Weeds		Wheat		Weeds	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Seed rate (kg/ha)												
75 kg/ha	109.7	103.2	6.9	7.9	19.6	19.5	1.6	1.7	96.5	100.1	7.8	9.6
100 kg/ha	112.7	119.1	6.5	7.5	21.2	22.3	1.4	1.6	98.8	103.9	7.4	9.1
125 kg/ha	116.7	122.9	6.0	7.0	23.1	24.5	1.3	1.5	101.6	111.9	7.2	8.5
150 kg/ha	115.3	104.7	5.6	6.6	22.4	23.9	1.2	1.4	100.2	108.5	6.3	8.0
CD (P=0.05)	NS	8.3	0.36	0.43	1.2	1.7	0.07	0.09	1.2	2.6	0.23	0.52
Weed control method												
Mechanical weeding At 15 and 30 DAS												
Rice straw mulch (2 tonnes/ha)	120.9	129.0	5.1	3.6	23.5	25.7	1.0	0.8	106.9	117.7	6.2	4.3
Neem oil spray (3%) at 30 DAS	116.9	115.5	5.2	6.9	22.4	23.2	1.1	1.5	101.0	109.9	6.2	8.3
Sulfosulfuron(25g/ha) at 30 DAS	106.9	96.9	5.3	7.8	21.9	19.5	1.2	1.7	94.0	93.5	6.3	9.6
Weedy check	120.1	127.9	5.0	3.5	22.9	25.5	1.0	0.8	105.0	116.4	6.1	4.3
	100.3	92.9	10.7	14.4	17.3	18.8	2.6	2.9	91.1	92.0	11.1	17.5
CD (P=0.5)	4.8	6.9	0.24	0.36	0.6	1.3	0.05	0.07	2.9	6.3	0.19	0.44

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EFFECT OF NITROGEN LEVELS AND ITS SPLIT APPLICATION ON NUTRIENT CONTENT AND QUALITY OF INDIAN MUSTARD (*BRASSICA JUNCEA* L.) IN ARID WESTERN RAJASTHAN

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Abstract

A field experiment was conducted during winter season of 2002-03 and 2003-04 to find out the effect of nitrogen levels and its split application on nutrient content and quality of Indian mustard (*Brassica juncea* L. Czernj. & Cosson). Application of increasing levels of nitrogen from 40 to 100 kg ha-1 significantly enhanced nitrogen content in mustard at 30, 60 & 90 DAS and in seed, phosphorus content in seed and +stover, potassium content in seed and stover, seed protein content and glucosinolate content of mustard. However, oil content in seed increased up to 60 kg N ha^{-1} after that decreased significantly. Further, application of nitrogen 1/3 as basal + 1/3 at 1st irrigation + 1/3 at 2nd irrigation being statistically at par with ½ at basal + ¼ at 1st irrigation + ¼ at 2nd irrigation brought a substantial improvement in nitrogen content in mustard plant at 90 DAS, in seed and stover and phosphorus content in seed of mustard as compared to two equal splits viz., ½ at basal + ½ at 1st irrigation, DAP basal + ½ of rest at 1st irrigation + ½ of rest at 2nd irrigation and 100 per cent basal. However significantly increase in nitrogen content at 30, 45 and 60 DAS and oil concentration was recorded due to nitrogen application as full basal over different split applications in mustard.

Key words : Indian mustard, nitrogen, split application, nutrient content, quality.

The world's arable land resources are finite and there is not much scope for significantly expending the area of land under cultivation. Hence, most of the increase in agricultural production will have to be obtained through increased productivity form the exiting agricultural land. This can be achieved by improved management practices in general and fertilizer management in practices in particular. Mustard is an important oilseed crop of India and stands next only to groundnut in term of both area and production.

Nitrogen is an indispensable element for optimum functioning of the crop and generally nitrogen fertilizer account for about half of the cost of cultivation for most of the crops (Prasad and Sarkar, 2002). Urea is the most widely used source of nitrogen by farmers all over the world. Efficiency of nitrogen use by most of the crops ranges from 20-60 per cent and commonly average around 50 per cent (Aulakh *et al.*, 1992). Low recovery of applied nitrogen by crops raise questions of the fate of the nitrogen that loss from soil plant system through runoff, leaching, denitrification and ammonia volatilization or made unavailable to the plant through biological immobilization. The soil of this region are deficient in organic matter, nitrogen and phosphorus content. These aspects of unstained crop production have received very little attention. Besides, the nitrogen levels, the time of application has also influenced the growth of mustard especially in light textured soils and high temperature. Thereafter, the present investigation was undertaken to find out the effect of nitrogen levels and its split application on nutrient content and quality of Indian mustard.

Materials and Methods

The experiment was conducted at college of Agriculture, Bikaner during winter season of 2002-03 and 2003-04. The soil was loamy sand and low in organic matter. The soil pH was 8.2. It was low in organic carbon (0.09%) available nitrogen (113.13 kgh^{-1}) and available phosphorus (12.01 kg ha^{-1}) and medium in potassium (200.04 kg ha^{-1}). The treatments comprised five levels of nitrogen (40,60,80,100 and 120kg N ha^{-1}) as main plot treatments and five split applications of nitrogen (100 per cent basal, ½ at basal + ½ at 1st irrigation, 1/3 as basal + 1/3 at 1st irrigation + 1/3 at 2nd irrigation , ½ at basal + ¼ at 1st irrigation + ¼ at 2nd irrigation and DAP basal + ½ of rest at 1st irrigation + ½ of rest at 2nd irrigation as sub pot treatment and were laid out in split plot design with three replication. Nitrogen as per treatments was applied through urea after adjusting the nitrogen(13.7 kg N) Supplied through DAP (applied for 35 kg P_2O_5 ha^{-1}). The calcutated quantity of urea for different treatments was applied basal and remaining nitrogen was given at 1st and 2nd irrigation as per treatments 30 and 60 days after sowing respectively. Indian mustard variety Bio-902 (Pusa Jikisan) was sown at 30 cm row spacing using 4 kg seed ha^{-1} on 29th and 27 October in 2002 and 2003, respectively.

RESULTS AND DISCUSSION

Effect of nitrogen levels

Application of graded levels of nitrogen up to 100 kg N ha^{-1} significantly increased the nitrogen content in mustard at 30 DAS, 60 DAS, 90 DAS and in seed, phosphorus content in seed and stover, potassium content in seed and stover, seed protein content and glucosinolate content of mustard. Whereas, the significant response of nitrogen at 45 DAS and in stover was observed up to 120 kg N ha^{-1} (Table 1). The magnitude of increase in nitrogen content of mustard with the application of 100 kg N ha^{-1} was 14.99, 7.48 and 3.01 per cent nitrogen content at 30 DAS, 10.57, 6.25 and 2.81 per cent nitrogen content at 60 DAS, 8.35, 4.57 and 1.57 per cent nitrogen content at 90 DAS, 5.38, 2.59 and 1.08 per cent nitrogen content in seed, 17.86, 9.57 and 3.41 per cent phosphorus content in seed, 7.69, 3.93 and 0.84 per cent phosphorus content in stover, 13.30, 6.75 and 1.84 percent potassium content in seed, 11.36, 4.63 and 1.83 per cent potassium content in stover, 5.34, 2.55 and 1.05 per cent seed protein content, 5.84,3.01 and 0.49 per cent glucosinolate content of mustard over 40,60 and 80 kg N ha^{-1} respectively. Further, application of 120 kg N ha^{-1} significantly increased the nitrogen content by 8.91, 5.84, 3.33 and 1.30 per cent in plant at 45 DAS and 28.07, 165.33, 8.55 and 3.36 per cent in stover over 40, 60, 80 and 100 kg N ha^{-1}, respectively.

Application of graded levels of nitrogen from 40 to 120 kg N ha^{-1} indicated that application of nitrogen up to 60 kg N ha^{-1} increased the oil content in seed of mustard but above 60 kg N ha^{-1} the oil content in mustard seed decreased significantly. Application of nitrogen at 60 kg ha^{-1} being statistically at par with 40 kg N ha^{-1} recorded significantly higher oil content over all higher levels of nitrogen. The reduction in oil content of mustard seed was recorded in order of 1.07 , 1.96 and 3.07 per cent due to application of 80, 100 and 120 kg N ha^{-1}, respectively as compared to 60 kg N ha^{-1} (Table 2).

It might be due to improved nitrogen availability in the root zone as well as nitrogen content in the plant system as a whole, leading to enhanced translocation especially of N, P and K to reproductive structures and plant parts. According to general pathway of degradation, carbohydrates are degraded to acetyl Co-A will be used for the synthesis of fatty acid by using acetyl carrying proteins (ACP) resulting in higher oil content in seed (Shukla and Kumar, 1994). Glucosinolate in the seds of mustard, nitrogen acts as a major facilitator for the formation of codon co-enzyme as well as essential component for the formation of precursor amino acids. The results obtained are also in agreement with findings of Bali *et al.* (2000) at Kashmir, Garnayak *et al.* (2001) at New Delhi and Mishra and Khurchania (2001) at Jabalpur in mustard and Grant *et al.* (2004) at Canada in canola (*Brassica napus*).

Effect of split application of nitrogen

Highest concentration of nitrogen content at 30 DAS, 45 DAS and 60 DAS and oil concentration was observed when nitrogen was applied as full basal as compared to all split applications (Table 1). The increase due to full basal was 2.57, 6.80, 2.57 and 6.99 percent in nitrogen content at 30 DAS, 1.61, 2.38, 2.09 and

Table 1. Effect of nitrogen levels and and their split application on nitrogen content (%) at various growth stages of mustard (pooled data of 2002-03 and 2003-04)

	Nitrogen content in mustard plant			Nitrogen content at harvest (%)		
	30 DAS	45 DAS	60 DAS	90 DAS	Seed	Stover
Nitrogen levels (kg/ha)						
40	2.87	0.998	0.861	0.718	2.935	0.456
60	2.768	1.027	0.896	0.744	3.015	0.502
80	2.888	1.052	0.926	0.766	3.060	0.538
100	2.975	1.073	0.952	0.778	3.093	0.565
120	3.012	1.087	0.956	0.782	3.109	0.584
SEm±	0.023	0.0013	0.0027	0.0014	0.0046	0.0008
CD (P=0.05)	0.068	0.0040	0.0081	0.0042	0.0138	0.002
Split application of N						
Basal 100%	2.952	1.072	0.934	0.686	2.951	0.472
½ Basal+1/2 at 1st irrigation	2.878	1.055	0.933	0.735	3.043	0.490
1/3 Basal+1/3 at 1st irrigation + 1/3 at 2nd irrigation	2.764	1.047	0.910	0.805	3.086	0.601
½ Basal+1/4 at 1st irrigation+1/4 at 2nd irrigation	2.878	1.050	0.908	0.802	3.052	0.489
DAP basal1 + ½ of rest at 1st Irrigation+1/2 of rest at 2nd irrigation	2.759	1.014	0.904	0.757	3.081	0.593
SEm±	0.022	0.0013	0.0026	0.0010	0.0041	0.0007
CD (P=0.05)	0.061	0.0036	0.0076	0.0028	0.0116	0.002

1st irrigation at 30 DAS, 2nd irrigation at 60 DAS, DAS=Days after sowing.

1=13.7 kg N/ha through DAP, 2=Nitrogen remaining after adjustment of 13.7 kg N/ha.

Table 2. Effect of nitrogen levels and their and split application on phosphorus, potassium, protein, glucosinolate and oil content at mustard (pooled data of 2002-03 and 2003-04)

Treatments	Phosphorus content (%)		Potassium content (%)		Protein content (%)	Glucosinolate content (μmol) g^{-1} seed)	Oil content (%
	Seed	Stover	Seed	Stover			
Nitrogen levels (kg/ha)							
40	0.515	0.221	0.684	1.197	18.34	98.52	37.94
60	0.554	0.229	0.726	1.274	18.84	101.22	38.08
80	0.587	0.236	0.761	1.309	19.12	103.76	37.67
100	0.607	0.238	0.775	1.333	19.32	104.27	37.33
120	0.607	0.237	0.772	1.332	19.43	104.47	39.63
SEm±	0.0052	0.00054	0.0021	0.0072	0.041	0.382	0.052
CD (P=0.05)	0.0157	0.0016	0.0064	0.0215	0.122	0.145	0.156
Split application of N							
Basal 100%	0.521	0.212	0.675	1.189	18.44	99.14	37.91
½ Basal+1/2 at 1st irrigation	0.551	0.218	0.688	1.203	19.01	102.31	37.68
1/3 Basal+1/3 at 1st irrigation+ 1/3 at 2nd irrigation	0.621	0.245	0.788	1.356	19.28	105.12	37.41
½ Basal+1/4 at 1st irrigation+1/4 at 2nd irrigation	0.592	0.243	0.783	1.349	19.07	104.60	37.64
DAP basal1 + ½ of rest at 1st Irrigation+1/2 of rest at 2nd irrigation	0.586	0.242	0.784	1.348	19.25	101.08	37.33
SEm±	0.0046	0.0004	0.0019	0.0070	0.041	0.224	0.046
CD (P=0.05)	0.0131	0.0013	0.0055	0.0195	0.115	0.719	0.129

1st irrigation at 30 DAS, 2nd irrigation at 60 DAS, DAS=Days after sowing.
1=13.7 kg N/ha through DAP, 2=Nitrogen remaining after adjustment of 13.7 kg N/ha.

5.72 per cent in nitrogen content at 45 DAS, 2.63, 2.86 and 1.73 percent in nitrogen content at 60 DAS, 0.61, 1.32, 0.71 and 1.53 per cent oil concentration over ½ at basal + ½ at 1st irrigation, 1/3 as basal + 1/3 1st irrigation + 1/3 at 2nd irrigation, ½ at basal + ¼ at 1st irrigation + ¼ at 2nd irrigation and DAP basal+ ½ of rest at 1st irrigation + ½ of rest at 2nd irrigation, respectively. Wherease, significantly higher nitrogen content in mustard plant at 90 DAS, in seed and stover and phosphorus content in seed when nitrogen was applied as 1/3 at basal + 1/3 at 1st irrigation + 1/3 at 2nd irrigation, however, it was statistically at par with ½ at basal + ¼ at 1st irrigation + ¼ at 2nd irrigation and these both treatments were statistically superior as compared all other split treatments of nitrogen. However, nitrogen application in three equal splits as 1/3 at basal + 1/3 at 1st irrigation + 1/3 at 2nd irrigation being statistically at par with ½ at basal + ¼ at 1st irrigation + ¼ at 2nd irrigation and DAP basal + ½ rest at 1st irrigation + ½ of rest at 2nd irrigation recorded significantly higher potassium content in seed and stover over two equal splits as ½ at basal + ½ at 1st irrigation and full basal (Table 2).

The magnitude of increase of nitrogen content at 90 DAS, in seed an stover, phosphorus content in seed and stover, seed protein content and glucosinolate content in seed due to splt application of nitrogen viz ½ at basal +1.2 at 1st irrigation, 1/3 at basal + 1./3 at 1st irrigation + 1/3 at 2nd irrigation, ½ at basal + ¼ at 2nd irrigation and DAP basal + ½ of rest at 1st irrigation + ½ of rest at 2nd irrigation was 7.14, 17.34, 16.91 and 10.35 percent nitrogen content at 90 DAS,3.12, 4.57 , 3.42 and 4.40 per cent nitrogen content in seed, 3.81, 27.33,3.60 and 25.63 percent nitrogen content in stover,5.75, 19.19, 13.62 and 12.47 percent phosphorus content in seed, 2.83, 15.56, 14.62 and 14.15 per cent phosphorus content in stover, 3.09, 4.55, 3.42 and 4.39 percent seed protein content and 0.84,3.54, 3.49 and 1.95 per cent glucosinolate content respectively, as compared to single application of nitrogen as 100 per cent basal.

The continuity of nutrient availability is maintained through split application which facilitates higher uptake o nitrogen, phosphorus and potassium as per requirement by plants (Kumar and Reddy, 1997). Thus more energy production under this regard might have stimulated the activities of necessary con-enzymes which ultimately led to higher synthesis of oleic, erucic acid and amino acids. Glucosinolate is the precursor of these substances, thus ultimately biosynthesisof glucosinolate is increased (Underhill *et al.*, 1962). Future, the inverse relationship between glucos inolate cotent with oil content in seed also proved the higher glucosinolate in mustard (Yadav and Kumari, 1993). These results are in conformity with those of Bali *et al.* (2000) at Srinagar, Singh *et al.* (2001) at Udaipur in sunflower, and Islam *et al.* (1992) at Bangladesh in mustard.

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EFFECT OF LAND CONFIGURATION AND NUTRIENT MANAGEMENT ON PRODUCTIVITY, ECONOMICS AND ENERGY REQUIREMENT OF PEARLMILLET (*PENNISETUM GLAUCUM*)- MUSTARD (*BRASSICA JUNCEA*) CROPPING SYSTEM

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Abstract

Field experiments were conducted at IARI, New Delhi, during the rainy and winter seasons of 2005-06 and 2006-07 on a sandy loam soil to study the effects of land configuration and nutrient management on economics and energy saving of pearlmillet [*Pennisetum glaucum* (L.)]-mustard (*Brassica juncea*) cropping system. Ridge and furrow sowing recorded significantly higher economic yield, by-product yield, energy output, net energy, energy efficiency, gross return (Rs. 23,458 & 24,621) and B:C ratio (2.22 & 2.33) in pearlmillrt-mustard cropping system than flay sowing during both the study years. Integrated supply of 30 kg N + 8.8 kg P + 6 t FYM/ha to pearlmillet recorded the highest economic yield (4152 & 3812 kg/ha), by-product yield, net return (37,124 & 36,902 Rs./ha) and B:C ratio which were similar to 60 kg N + 17.6 kg P/ha but significantly higher in remaining integrated nutrient management (INM) treatments. Application of 60 kg N + 17.6 kg P/ha to mustard also further improve the yield, economics and energy efficiency of this system

Key words : Cropping system, energy saving, Farm yard manure, land configuration, mustard, pearlmillet.

Pearlmillet-mustard cropping system is predominant in North-Western India, because of its higher productivity and profitability and lower water input and labour requirements compared to other perlmillet based cropping system. However, to realize higher productivity and income from Pearlmillet-mustard cropping system, important production technologies like nutrient management, crop establishment practices, etc. need to be developed for this system. Integrated nutrient management aims at sustainable crop production with minimum deleterious effect of chemical fertilizers on soil health and least disturbance to the agro-ecosystem by orchestrating the combined use of inorganic fertilizers and organic manures. This approach restores and sustains soil health, productivity saves energy and improves economics in the long run, besides meeting the nutritional deficiencies (Satyajeet and Nanwal, 2007). Ridge and furrow sowing sowing has been shown to enhance the yield, energy saving and monetary returns. Hence the present investigation was carried out to find out suitable crop establishment methods and nutrient management options.

Materials and Methods

Field experiments were conducted at the Research Farm of IARI, New Delhi during the rainy and winter seasons of 2005-06 and 2006-07. The surface soil of the study site was sandy loam containing 0.39% organic Carbon and 135.4, 12.8 and 178.8 kg/ha available N, P and K, respectively. The total rainfall received during experimental period was 506.1 mm in 2005-06 and 495.7 mm in 2006-07. The treatments included two land configurations (flat sowing and ridge & furrow sowing) and five fertility levels control, 30 kg N + 8.8 kg P/ha, 60 kg N + 17.6 kg P/ha, 30 kg N + 8.8 kg P + 6 t FYM/ha and 6 t FYM/ha alone) laid out in randomized block design for pearlmillet. During winter season the experiment was laid out in splitplot design with land configurations and preceding nutrient levels applied to pearlmillet in the main plots and three direct nutrient levels (control, 30 kg N + 8.8 kg P/ha and 60 kg N + 17.6 kg P/ha) to succeeding mustard in sub-plots. These treatments were replicated thrice. Data recorded from peralmillet and mustard crops from two consecutive years were statistically analyzed by using the F -test as per the procedure given by Gomez and Gomez (1984). LSD at P=0.05 were used to determine the significanct difference between treatment means. The nitrogen was applied through urea and phosphorus through singles super phosphate. The well decomposed farm yield manure was incorporated in the soil 2 weeks before sowing. Pearlmillet ('Pusa Compositae-383') was sown 3rd week of July and harvested in 2nd week of October in both the years keeping 50 cm x 15 cm spacing. Mustard (Pusa Agrini) was sown after pearlmillet in 3rd week of October keeping row spacing of 45 cm. Other management practices were adopted as per recommendations for the crops under limited irrigated conditions.

RESULTS AND DISCUSSION

Effect of land configuration

Ridge and furrow sowing significantly increased economics and by-product yields of pearlmillet-mustard cropping system over the flat sowing both in 2005-06 and 2006-07 (Table 1). Similar effects of land configuration have also been reported by Kantwa *et al.* (2006). Energy requirement for pearlmillet-mustard cropping system was 5.5 per cent higher under ridge and furrow sowing compared to flat sowing (13709 MJ/ha) as constructing ridges and furrow involved expanding of more energy. Total energy out put, net energy and energy use efficiency were significantly raised by the ridge and furrow over flat sowing. On an average the former method of sowing resulted in 13.14, 13.84 and 13.85% gain in total energy out put, net energy and energy use efficiency, respectively, over the latter (Table 1).

Similar results have also been reported by Singh *et al.* (1997) and Mandal *et al.* (2002). Data in Table 2 revealed that profit wise also ridge and furrow method of sowing with average net returns of Rs. 24490 and B:C ratio of 2.27 proved significantly superior to flat sowing (net return Rs. 21078 and B:C ratio 2.11).

Effect of nutrient management to pearlmillet

Integrated application of 30 kg N + 8.8 kg P + 6 t FYM/ha significantly increased economic yield and by-product yield of pearlmillet-mustard cropping sequence (Table 1) over control, 30 kg N + 8.8 kg P/ha and 6 t FYM/ha alone, but, remained at par with 60 kg N + 17.6 kg P/ha in both the years. This might be due to the role of FYM in improving soil physico-chemical and biological properties leading to increased nutrients and water availability and this resulting in better root growth and development. These results are in close conformity with the findings of Satyajeet *et al.* (2007). The energy requirement varied from 11,599 & 11,865 MJ in control to 15,679 and 15,945 MJ in fertility level of 60 kg N + 17.6 kg P/ha. However, the gross energy output was the highest (194020 MJ) under integrated application of 30 kg N + 8.8 kg P + 6 t FYM/ha which was 0.86% higher than the fertility level of 60 kg N + 17.6 kg/ha and 32.42% higher than control (Table 1).

The maximum net energy (1,90,571 MJ) in 2005-06 was recorded with fertility level of 30 Kg N + 8.8 kg P + 6 t FYM/ha while in 2006-07 it was observed with 60 kg N + 17.6 kg P/ha (1,66,609 MJ). Energy efficiency in 2005-06 was maximum (13.72) with control while in 2006-07 it was maximum (12.02) with sole application of 6 t FYM/ha. These results are in conformity with Singh *et al.* (1997).

Application of 60 kg N + 17.6 kg P/ha to pearlmillet fetched highest net return (Rs. 25,223) in 2005-06, while in 2006-07 it was highest (Rs. 25,692) with 30 kg N + 8.8 kg P + 6 t FYM/ha. However, the B:C ratio was highest (2.35 and 2.37) with preceding application of 60 kg N + 17.6 kg P/ha in pearlmillet-mustard cropping sequence, and minimum with control (2.06 and 2.00) during 2005-06 and 2006-07, respectively (Table 2).

Effect of directly applied nutrients to mustard

Application of 60 kg N + 17.6 kg P/ha to

Table 1. Effect of land configuration and direct and residual nutrient management on energy input-output relationship of pearlmillet-mustard cropping system

Treatments	Energy Requirement (MJ/ha)		Economic yield (kg/ha^{-1})		By-product yield (kg/ha^{-1})		Energy output (MJ/ha^{-1})		Net energy (MJ/ha^{-1})		Energy efficiency (output-input ratio)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Land configuration												
Flat sowing	13576	13842	3498	3177	9884	8528	174969	153295	161393	139454	13.0	11.2
Ridge & furrow sowing	14326	14592	3872	3634	10996	9890	194376	177039	180050	162447	13.7	12.3
SEm ±	-	-	47.43	40.98	143.61	145.08	2406	2081	2306	2081	0.2	0.2
CD (P=0.05)	-	-	141	122	427	431	6850	6183	6850	6183	0.5	0.5
Nutrient management (Pearlmillet)												
Control	11599	11865	3078	2766	8949	7620	157123	135911	145524	124046	13.7	11.6
30 kg N + 8.8 kg P/ha	13639	13905	3571	3346	10054	9079	178182	162676	164543	148771	13.2	11.8
60 kg N + 17.6 kg P/ha	15679	15945	4043	3731	11460	10177	202673	182054	186994	166609	13.0	11.5
30 kg N+8.8 kg P+6t FYM/ha	15439	15705	4152	3812	11598	19979	206010	182031	190571	166326	13.4	11.7
6t FYM/ha	13399	13665	3580	3371	10140	9089	179375	163164	165976	149499	13.5	12.0
SEm ±	-	-	75.00	64.80	277.06	229.39	3646	3291	3646	3291	0.3	0.3
CD (P=0.05)	-	-	223	183	675	681	10830	9777	10830	9776	NS	NS
Direct applied nutrient (mustard)												
control	11911	12172	3467	3217	9902	8665	174729	155603	162818	143426	14.7	12.8
30 kg N + 8.8 kg P/ha	13951	14217	3737	3465	10539	9389	186675	168290	172724	154073	13.4	11.8
60 kg N + 17.6 kg P/ha	15991	16257	3851	3533	10880	9573	192613	171608	176622	155351	12.0	10.5
SEm ±	-	-	28.15	20.05	120.25	66.40	1817	1058	1817	1058	0.1	0.1
CD (P=0.05)	-	-	80	57	344	190	5193	3024	5193	3024	0.3	0.2

Table 2. Effect of land configuration and direct and residual nutrient management on economics of pearlmillet-mustard cropping system

Treatments	Cost of cultivation (Rs./ha)		Gross return (Rs./ha)		Net return (Rs./ha)		B:C ratio	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Land configuration								
Flat sowing	9806	10049	31005	31006	21199	20957	2.2	2.1
Ridge & furrow sowing	10772	10549	34231	35170	24358	24621	2.2	2.3
SEm ±	-	-	318	270	318	270	0.03	0.03
CD (P=0.05)	-	-	944	802	944	802	0.09	0.08
Nutrient management (Pearlmillet)								
Control	8820	9057	27021	27242	18201	18184	2.1	2.0
30 kg N + 8.8 kg P/ha	9765	10010	31305	32285	21540	22275	2.2	2.2
60 kg N + 17.6 kg P/ha	10710	10962	35933	36232	25223	25270	2.2	2.4
30 kg N+8.8 kg P+6t FYM/ha	12132	11210	37124	36902	24992	25692	2.2	2.3
6t FYM/ha	10020	10257	31705	32780	21685	22523	2.2	2.2
SEm ±	-	-	502	427	502	427	0.1	0.04
CD (P=0.05)	-	-	1492	1267	1492	1267	0.2	0.12
Direct applied nutrient (mustard)								
Control	9111	9347	28857	29972	19746	20626	2.2	2.2
30 kg N + 8.8 kg P/ha	10056	10299	33601	33715	23545	23415	2.3	2.3
60kg N + 17.6 kg P/ha	11702	11252	35395	35578	23694	24326	2.1	2.2
SEm ±	-	-	465	366	465	366	0.05	0.04
CD (P=0.05)	-	-	1329	1045	1329	1045	0.14	0.10

mustard significantly improved economic yield and by product yield of pearlmillet-mustard cropping system over control and 30 kg N + 8.8 kg P/ha in both the years of study (Table 1). This might be due to continued and balanced supply of nutrients enhancing their availability and uptake resulting in better root and shoot growth which consequently led to higher yield of both the crops. A higher (34.25 & 33.5 and 14.62 & 14.35%) energy requirement was recorded in pearlmillet-mustard cropping sequence due to application of 60 kg N + 17.6 kg P/ha over control and 30 kg N + 8.8 kg P/ha respectively, in both the years.

An energy output of (1,92,613 & 1,71,608, 1,86,675 & 1,6,8290 and 1,74,729 & 1,55,603 MJ) was recorded with fertility levels of 60 kg N + 17.6 kg P/ha, 30 kg N + 8.8 kg P/ha and control, respectively during both the years of study (Table 1). The variation in total energy output was due to variation in yield of crops with fertility levels. Similar pattern of energy output was earlier observed by Mandal *et al.* (2002). The maximum net energy (1,62,818 & 1,43,426 MJ) as well as energy use efficiency (14.70 & 12.78) were observed with control in 200-06 and 2006-07, respectively. Application of 60 kg N + 17.6 kg P/ha yielded the lowest net energy and energy efficiency.

However, the latter treatment fetched the highest net returns Rs. 23,694 and 24,326) and the former (control) fetched the lowest (Rs. 19,746 and 20,626) in both the years. B:C ratio was the highest (2.33 and 2.26) with direct application of 30 kg N + 8.8 kg P/ha and the lowest (2.08 and 2.15) with 60 kg N + 17.6 kg P/ha during both the years (Table 2).

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EFFECT OF DIFFERENT ORGANIC MANURES AND SPACING ON *ALOE VERA* L.

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ABSTRACT

An on-farm trial was conducted during 2006 and 2007 at a farmers field in Salem district of Tamil Nadu, to study the effect of different organic manures and spacing on medicinal plant *Aloe vera*. The different organic manures as well as spacing significantly influenced the growth and yield of *A. vera*. Application of neem cake @ 1.50 t/ha and spacing of 90 x 90 cm recorded the highest leaf yield of 56.24 t/ha.

Key words : *Aloe vera*, agronomic practices, organic manures, spacing.

Aloe vera L. is an important medicinal plant belonging to the family Liliaceae. It is a perennial, drought resistant, succulent plant with a whorl of elongated pointed fleshy leaves. *A. vera* has a larger demand in medicinal drug market in the world. *A. vera* sap contains cathartic anthraxglycosides as its active principle ranging from 4.5 to 25 per cent of aloin. Recent studies indicate that herbal remedies are gaining their performance, because of the observation that the efficacy of allopathic medicines such as antibiotics, which once had near universal effectiveness against serious infections in on the wane. Over the years, infectious agents have developed resistance to synthetic drugs and the herbs and their active constituents are now being increasingly used to treat various diseases like ulcers, healing of cancer sores, burns, itching, fever, tuberculosis and paralysis. Aloe products have long been used in health foods, medicinal purpose and cosmetics (Morton, 1961). These products range from aloe drinks to aloe gels, powders, capsules, creams etc. for both internal and external uses for a wide variety of indications. Several patents have been registered especially for cosmetic uses of aloe leaves. Hence the cultivation of *A. vera* has acquired great commercial importance for medicinal products and cosmetic processing but information are scarce about agronomic management of this crop. Further the organic cultivation of the crop is also gaining importance, because the product used in food, medicinal and cosmetic industries and the organic. *A. vera* is expected to be a better marketable product. Keeping this fact in view, the present trial was undertaken to standardize the agro techniques for *A.. vera*.

MATERIALS AND METHODS

On-farm trial was conducted at farmer's field in Salem district, Tamil Nadu during 2006 and 2007, to standardize the organic manures and spacing for cultivating the medicinal plant *A. vera*. The soil of the experimental field was sandy loam with pH of 6.9 and was low in available nitrogen (194 kg N/ha), medium in available phosphorus (16.8 kg P/ha) and high in available potassium (321 kg K/ha). The raised sand bed nursery was prepared to a height of 15 cm, width of one meter and length of 10 meter and length of 10 meters. The rhizome was used as a propagative material for cultivating *A. vera*. The underground root of the mother plant was dug out and made into 6-7 cm long pieces having 2-3 nodes on them. These are directly planted in the sand bed at a spacing of 4 cm. Regular watering was done for establishment of cuttings. The cuttings were ready for transplanting after 60 days. The experimental field was thoroughly prepared and it was laid out in a split plot design with three replications of plot size of 8 x 8 meters. The main treatments comprised organic manures *viz.*, neem cake @ 1.50 t/ha, farmyard manure @ 12 t/ha, vermicompost @ 10 t/ha and control. The sub treatment consisted three spacing *viz.*, 60 x 60, 75 x 75 and 90 x 90 cm. The plot was individually supplied with the organic manure as per the treatment schedule. Full quantity of all the organic manures were applied to the field as basal dose. Sixty days old rhizomes were planted at different spacing as per the treatment schedule. Irrigation was done immediately after planting. The subsequent irrigations were done by adopting the drip irrigation system, depending upon the moisture status of the soil. All the intercultural operations were done as and when required. The side shoots produced from the main plants were frequently removed for increasing the main plant height. The plants were harvested after nine months of planting. The leaves were cut transversally at the bottom. The observations recorded were plant height, number of leaves/plant, leaf weight/plant, gel weight/plant, leaf yield/hectare, and leaf: gel ratio. The leaf : gel ratio was calculated by dividng the values of the weight of the gel with the corresponding values of the weight of whole leaf and expressed in number. The pooled data of two years were statistically analyzed and least significant difference was worked out at 5 per cent probability level (Panse and Sukhatme, 1978).

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RESULTS AND DISCUSSION

Effect on growth parameters

All the treatments significantly influenced the growth parameters of *A. vera* (Table 1). Among the different organic manures, application of neem cake @ 1.5 t/ha resulted in taller plants of 90.05 cm and higher number of leaves 15.40 per plant. This was followed by application of farmyard manure @ 12 t/ha and vermicompost @ 10 t/ha. This might be due to the better and slow release of nutrients from organic manures throughout the crop growth. The same result was reported by Iyer (2004). The shorter plant height and lower number of leaves per plant were recorded with untreated control. Among the spacing, 60 x 60 cm recorded the taller plants of 89.10 cm at harvest stage. This might be due to closer spacing which could be attributed to competitive interaction for light and better utilization of resources. The higher number of leaves 15.45 per plant recorded with spacing of 90 x 90 cm giving more room for crop canopy. This result is in concomitance with the reports of Singh and Singh (1979).

Effect on yield components

Yield components of *A. vera* were significantly influenced by the organic manures and spacing (Table 1). Highest leaf weight of 6.38 kg/plant, gel weight of 3 kg/plant, leaf yield of 43.95 t/ha, gel yield of 19.40 t/ha and leaf : gel ratio of 0.44 were recorded with neem cake @ 1.50 t/ha. This could be attributed to the higher rate of metabolic functions contributing for increased growth and conopy coverage by virtue of better nutrient availability and uptake. This was in conformity with the earlier reports of Singh and Nand (1979). Neem cake was followed by the application of farmyard manure @ 12 t/ha and vermicompost 10 t/ha. The lowest leaf and gel weight per plant, leaf and gel yield/ha and leaf: gel ratio were obtained with untreated control. Among the different spacing, 90 x 90 cm recorded highest leaf weight of 6.50 kg/plant, gel weight of 3.10 kg/plant, leaf yield of 46.90 t/ha, get yield of 20.63 t/ha and leaf: gel ratio of 0.44. This might be due to increased number of leaves in the individual plant and efficient utilization of available nutrients by the plants, which resulted in the rapid development of leaf and gel yield. The present result is in line with the reports of Saha *et al.* (2005). The interaction effect between organic manures and spacing was also significant (Table 2). The highest leaf yield of 56.42 t/ha was recorded with the application of neem cake @ 1.50 t/ha, and spacing of 90 x 90 cm. The lowest leaf yield of 21.90 t/ha was recorded in the control and the spacing of 60 x 60 cm.

Table 1. Effect of organic manures and spacing on growth and yield components of *A. vera* (Pooled data of 2006 and 2007)

Treatment	Plant height (cm)	Number of leaves/ plant	Leaf weight/	Gel weight/ plant (kg)	Gel yield (t/ha) plant (kg)	Leaf : gel ratio
Organic manures						
Control	68.85	12.10	3.76	1.25	7.23	0.33
Neem cake @ 1.50 t/ha	90.05	15.40	6.38	3.00	19.40	0.44
Farmyard manure @ 12 t/ha	86.00	14.01	5.80	2.45	17.93	0.43
Vermicompost @ 10 t/ha	85.00	13.39	5.60	2.27	17.45	0.42
CD (P=0.05)	3.50	1.38	0.50	0.44	1.25	0.11
Spacing						
60 x 60 cm	89.10	12.94	4.52	1.70	10.19	0.36
75 x 75 cm	85.70	13.47	5.18	2.22	13.94	0.38
90 x 90 cm	80.00	15.45	6.50	3.10	20.63	0.44
CD (*P*=0.05)	2.81	1.80	0.80	0.60	2.71	0.14

Table 2. Interaction effect of organic manures and spacing on the leaf yield of *A. vera*

Organic manures	Sapcing			
	60 x 60 cm	75 x 75 cm	90 x 90 cm	Mean
Control	20.10	21.90	23.75	21.92
Neem cake @ 1.50 t/ha	32.60	43.00	56.24	43.95
Farmyard manure @ 12 t/ha	30.48	41.28	54.10	41.95
Vermicompost @ 10 t/ha	30.00	40.66	53.50	41.39
Mean	28.30	36.71	46.90	-

Organic manure (OM) : CD (*P*=0.05) - 1.25

Spacing (S) : CD (*P*=0.05) - 1.75

Interaction

OM x S : CD (*P*=0.05) - 2.10

S x OM : CD (*P*=0.05) - 3.00

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INTER-RELATIONSHIP AMONG QUANTITATIVE CHARACTERS AND PATH COEFFICIENT STUDIES IN *KABULI* CHICKPEA (*CICER ARIETINUM* L.)

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ABSTRACT

Correlation and path coefficient analysis for yield components were carried out in 38 *kabuli* chickpea genotypes. Biological yield per plant, hundred seed weight, harvest index, seeds per pod and primary branches per plant showed positive and significant association with seed yield. Path coefficient analysis further indicated that biological yield per plant had the highest direct effect on seed yield followed by harvest index, 50% flowering, 100 seed weight and primary branches per plant. Thus, in present situation biological yield per plant, 100 seed weight, harvest index and primary branches per plant are the important parameters that have direct influence on seed yield per plant, there by suggesting that these traits should be given due weightage in selection of superior genotypes for rainfed *kabuli* chickpea.

Key words : Correlation, path coefficient analysis, rainfed *kabuli* chickpea.

Yield is a complex character and is determined by many component traits. The identification of important characters and their inter-relationship would be useful for developing improved genotypes. Further the association between various yield attributes with seed yield provides a basis for breeding strategies, but they do not give an exact picture of the relative importance of direct and indirect effects of the various attributes of independent characters. Path analysis proposed by Wright (1912) is useful technique designed to ascertain the path along which relationship among variables. It facilitates the understandin causal relationships among interrelated variables, which confirm the importance of these quantitative traits for their contribution towards seed yield. Thus the present study was undertaken to determining the degree and direction of association and furnishes additional information of path coefficient analysis in rainfed *kabuli* chickpea.

MATERIALS AND METHODS

The experiment material comprised of 38 *kabuli* chickpea genotypes was grown in complete randomized block design with 3 replications at Research Field of R.A.K. College of Agriculture, Sehore (M.P.) during *rabi* season of 2005-06. Each plot consisted 4 rows of 4 m length with the spacing of 30 cm and 10 cm between and within the row, respectively. Recommended package of practices were adopted for optimum crop growth. Detailed observations were recorded on 5 randomly chosen plants from each entry in every replication on days to flower initiation, days to 50% flowering, number of primary branches, number of secondary branches, pod initiation, 50% podding, number of seeds per pod, biological yield per plant, seed yield per plant, harvest index and 100 seed weight.

The mean values of each character were taken for statistical analysis. Phenotypic and genotypic correlation coefficients were estimated by the method described by Aljibouri *et al.* (1958). Path coefficient analysis suggested by Dewey and Lu (1959) was utilized to partition the correlation into direct and indirect effects ·

RESULTS AND DISCUSSION

Correlation coefficient as mentioned in Table 1, indicated that Seed yield per plant showed positive and significant correlation with biological yield per plant (0.694**), hundred seed weight (0.457**), harvest index (0.429**), seeds per pod (0.248**), and primary branches per plant (0.228*). The result was supported by findings of Mishra *et al.* (1988), Jivani and Yadavendra (1988), Khorgade (1995) and Khedar *et al.* (1999)

Important yield contributing characters are positively and negatively correlated with seed yield. It is therefore necessary to study the direct and indirect effects of various component traits on seed yield. In such situations path coefficient analysis provides the useful information by partitioning the correlation coefficient into direct and indirect effects. In the present investigation maximum positive direct effect on seed yield was exhibited by biological yield per plant (0.936) followed by harvest index (0.680), 50% flowering (0.291), 100 seed weight (0.036) and primary branches per plant (0.017). Most of the quantitative traits had contributed indirectly via biological yield (Table 2). These results further confirmed the importance of these characters for their contribution towards seed yield of *kabuli* chickpea. These results are in accordance with the findings of Yadav et al. (1999) for biological yield per plant, 100 seed weight and harvest index, Khedar and Maloo (1999) for 100 seed weight and primary branches per plant, Toker and Cagirgah (2003) and Muhammad (2004) for biological yield and harvest index. The present investigation indicated that selection for biological yield per plant, harvest index, 100 seed weight and primary branches per plant should be the selection criterion to improve the seed yield in rainfed *kabuli* chickpea.

Table 1. Estimates of genotypic, phenotypic and environmental crrelation cefficients among quality traits in *kabuli* chickpea

Characters		100 seeds weight after soaking	Hydration capacity	Hydration index	Volume fo 100 weed	Volume fo 100 weed after soaking	Swelling capacity	Swelling index	Seed yield
100 seed weight	G	0.972	0.912	-0.233	0.974	0.937	0.833	0.056	0.487
	P	0.972*"	0.910*"	-0.233*	0.959*"	0.935**	0.827*"	0.055	0.457**
	E	-o.1~:	-0.506	-0.835	0.026	0.110	0.068	-0.037	-0.009
100 seed weight after soaking	G		0.983	0.000	0.958	0.929	0.831	0.088	0.439
	p		0.982*"	0.002	0.943*"	0.927**	0.824*"	0.086	0.413**
	E		0.930	0.616	-0.040	0.006	0.039	0.007	0.087
Hydration capacity	G			0.183	0.908	0.886	0.796	0.110	0.384
	P			0.187*	0.893**	0.883**	0.789**	0.108	0.361**
	E			0.852	-0.044	-o.03U	0.007	0.021	0.079
Hydration Index	G				-0.175	-0.143	-0.112	0.120	-0.226
	P				-0.172	-0.142	-0.110	0.118	-0.210*
	E				-0.034	-0.056	-0.016	0.032	-0.001
Volume of 100 seed	G					0.906	0.771	-0.015	0.510
	P					0.893**	0.741**	-0.037	0.483**
	E					0.269	-0.623	-0.627	0.189
Volume of 100 seed after SOIldng	G						0.968	0.391	0.444
	P						0.964**	0.389**	0.419**
	E						0.586	0.534	0.118
Swelling capacity	G							0.597	0.366
	P							0.604**	0.339**
	E							0.961	-0.063
Swelling Index	G								-0.039
	P								-0.040
	E								-0.057

* and ** significant at 5% and 1% levels, respectively

Table 2. Genotypic (G) and phenotypic (P) path coefficient showing direct (bold) and indirect effects of qualitative characters influencing seed yield of *kabuli* chickpea

Characters	Type of path coefficient	100 Seed weight	100 seed weight after soaking	Hydration capacity	Hydration Index	Volume of 100 seed	Volume of 100 seed after socking	Swelling capacity	Swelling Index	Correlation coefficient wtih seed yield
		1	2	3	4	5	6	7	8	9
100 seed weight	G	2.763	-0.070	-3.706	-0.358	-2.868	8.917	-4.153	-0.040	0.487
	P	1.800	1.471	-3.601	-0.268	0.795	-0.515	0.793	-0.017	0.457**
100 seed weight after soaking	G	2.686	-0.072	-3.993	0.000	-2.820	8.842	-4.141	-0.063	0.439
	p	1.749	1.514	-3.886	u.002	0.781	-0.511	0.791	-0.027	0.413**
Hydration capacity	G	2.520	-0.070	-4.064	0.282	-2.672	8.436	-3.969	-0.079	0.384
	p	1.639	1.487	-3.956	0.215	0.739	-0.487	0.757	-0.034	0.361**
Hydration Index	G	-0.643	0.000	-0.745	1.538	0.515	-1.362	0.557	-0.086	-0.226
	P	-0.419	0.002	-0.738	1.151	-0.142	0.078	-0.106	-0.037	-0.210*
Volume of 100 seed	G	2.692	-0.068	-3.688	-0.269	-2.944	8.621	-3.842	0.011	0.510
	P	1.727	1.428	-3.532	-0.198	0.828	-0.492	0.711	0.012	0.483**
Volume of 100 seed after socking	G	2.589	-0.066	-3.602	-0.220	-2.667	9.518	-4.827	-0.281	0.444
	p	1.683	1.403	-3.494	-0.163	0.740	-0.551	0.924	-0.122	0.419**
Swelling capacity	G	2.302	-0.059	-3.235	-0.172	-2.269	9.214	-4.986	-0.428	0.366
	P	1.488	1.248	-3.123	-0.127	0.613	-0.531	0.959	-0.189	0.339**
Swelling index	G	0.155	-0.006	-0.447	0.185	0.043	3.725	-2.977	-0.717	-0.039
	P	0.098	0.130	-0.426	0.135	-0.031	-0.214	0.579	-0.313	-0.040

* and ** significant at 5% and 1% levels, respectively

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LINKAGE STUDIES OF EXISTING AND INDUCED MUTANTS TRAITS IN CHICKPEA (*CICER ARIETINUM*)

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ABSTRACT

The present investigation was carried out at livestock farm, Deptt of Plant Breeding & Genetics with the objective to detect and estimate linkages between new mutants and existing morphological traits. The crosses under study were A I x Multi, Fas x OCW, BFL (Y) x OCW, BFL (Y) x Multi, A3 (YT) x OCW, Fas x Vari, Fas x YT, Comp x Vari A3 (Fas) x YT, JGGI x C. seed, Comp x yellow top. The linkages were detected between simple leaves (*slv*) and cracked seed (C*rs*) (25 ± 1.0cM). A contingency χ^2 value of 4.559 was estimated, which is highly significant (P=O.033) and showed that slv and Crs are linked. The linkages between variegation with curling of leaves and multipinnated leaves with fascinated stem exhibited deviation. The compact internode with compact leaflet, and compact internode with pod disposition showed distortion due to pleiotropic effects. However, the single plant with lax leaflet/internode with upper pod position can be exploited for basic studies.

Key words : Linkage, mutant, pleiotrophy, segregation, traits.

Chickpea (*Cicer arietinum* L.) is a self-pollinated diploid (2n=2x=16) legume of the tribe *Cicerae,* family leguminosae and subfamily papilionoideae. Chickpea is the most important pulse crop of India and the third most important pulse crop of the world. India alone contributes about 70% to the global chickpea production. Madhya Pradesh is the largest chickpea producing state of India contributing nearly one third to the Indian chickpea production.

In the past, attempts have been made to construct gene map of chickpea using morphological traits. The available information is meager, to fully establish any linkage group. The existence of wide morphological diversity in chickpea offer ample opportunity for genetic studies. The inheritance studies can uncover genetic mechanism of several traits. Understanding the inheritance of traits improves the efficiency, predictability and effectiveness of breeding efforts. The linkage of genes for economical identifiable markers can improve the efficiency of breeding and hasten the development of improved cultivars. Bhat and Argikar (1951) reported the first linkage in *Cicero* The new information added to extend the linkage of traits in chickpea can increase the efficiency of plant breeding programmes.

Genome mapping is a continuous process and requires efforts of many laboratories. Much work is still needed on the genetics of Cicer particularly in the area of identifying useful new genetic markers and constructing accurate linkage maps for the eight chromosomes. Development of a high density linkage map of chickpea will facilitate tagging genes of economic importance; marker-assisted selection and map based cloning of genes. This work is an attempt to add additional genes on linkage map of chickpea by detecting and estimating linkages between new mutants and existing morphological traits.

MATERIALS AND METHODS

The F_2 seeds of different spontaneous and induced mutant traits over different crosses were supplied by chickpea breeder, Department of Plant Breeding and Genetics, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. The present study has been conducted during 2003-04 using segregating population (F_2) involving eleven cross combination from fifteen marker traits *viz.* seven mutant markers (Ethyl Methane Sulphonate induced), three double recessive mutants (derived from the crosses involving mutants induced at JNKVV, Jabalpur) and four traits from three accession. Plants were grown in the experimental fields situated at the Breeder's Seed Production Farm, J.N.K.V.V.; Adhartal, Jabalpur. The mutants (induced), accessions with existing morphological traits (spontaneous mutants) and their crosses were studied with the characters Stem fasciation (FAS), Leaf variegation (VAR), Broad few leaflets (BFL) Multiflowered (MDL TI), Curlyness of leaflet margin in variegata (CURL- V AR), Outwardly curved wing in flower (OCW), Yellow foliage, Yellow top canopy, Multipinnated leaves, Compact internodes, Compact leaflets, Reticulated seed (Table 1). The linkages were detected by contingency χ^2 test on joint segregation of pair of loci

RESULTS AND DISCUSSION

A linkage was detected between the loci *slv* (simple leaves) and *Crs* (cracked seed) from the cross JGGI X Cracked seed. Out of 54 plants examined in the F_2, 21 plants had bipinnated leaves and normal seed, 11 had simple leaves and cracked seed, and 2 plants had simple leaf and cracked seed (Table 2). A contingency χ^2 value of 4.559 was estimated, which highly significant (P=0.033) and indicated that *slv* and *Crs* are linked. A recombination value of 23.25 ± 1.0cM was estimated between the two loci (Table 2). Similarly loci 'V' (variegated leaves) with leur (curling of leaflet margin), ieomp (compact

Table 1. Details of mutant/other traits and their character description

S.No	Character (Source-abbreviated)	Characters Description
Mutants (Induced)		
I	Stem fasciation (F AS)	Stem becomes flattened and leaves show irregular arrangement
2	Leaf variegation (V ARI)	Large single lesion of chlorosis at each side of lamina of all leaflets and curling of leaflets
3	Broad-few-leaflets (BFL)	Fewer (5-9) leaflets of relatively bigger size
4	Multiflowered (MDL TY)	One to nine flowers on each flowering node arranged in cymose inflorescence
5	Yellow Top (YT)	The developing shoot canopy of the plants have yellow colour
6	Outwardly Curved Wing (OCW)	The wing in old flowers outwardly curved
7	Compacta (COM)	The leaflet and stem internodes are compactly arranged
Double Recessives		
8	Broad Few Leaflets -Light foliage: BFL (Y)	Fewer (5-9) leaflets of relatively bigger size and Light foliage colour
9	Multipinnate leaves -Yellow top: A3 (YT)	Multipinnate leaves and yellow coloured developing shoots
10	Multipinnate leaves -Fasciated stem A3 (FAS)	Multipinnate leaves and Fasciated stem
Other Morphological Traits (Spontaneous mutants)		
11	ICC 4929 (AI)	White and pink striped flower and twin podded
12	JGGI (A2)	White flowered and seed coat.
13	Crack Seed (CS)	Seed coat with cracks
14	ICC 5316 (A3)	Multipinnate leaf, pea shaped seed

Table 2. Contingency 2 X 2 tests for segregation data of pairs of loci in a linkage group of *Cicer arietinum*

S.No.	F_2 Family	F_2 Phenotypes				X2	P	R+S.E.
		BPUNcr	SlvlNcr	BPLICrs	SlvlCrs			
1	JGGI x Crack Seed	21	11	20	2	4.5500	0.033	23.25 ± 1.00
		NVINC	VINC	NVIC	VIC			
2	COMPx VARI	388	3	a	108	3199.2	0.000	0.63 ±4.40
	FASxYT	273	4	1	57	2186.8	0.000	0.16 ± 0.16
		LIINP	CIINP	LIIPd	CIIPd			
3	COMPxYT	86	63	6	21	11.54	0.001	23.00 + 5.70
		LLINP	CUNP	LUPd	CLIPd			
4	COMPxYT	149	a	1	26	168.35	0.000	1.31+ 7.50
		BPLINF	MPLIN	BPLIF	MPLIF			
5	A3(FAS) x YT	28	15	15	1	4.83	0.020	23.00+ 12.00
		IYiJ	CIILL	LIICL	CIICL			
6	COMPxYT	~()	65	6	20	10.19	0.010	25.00 ± 5.80

Slv	Simple leaves	LI	Lax internode
BPL	Bipinnated leaves	LL	Lax leaflet
Ncr	Non cracked seed	CI	Compact internode
Crs	Cracked seed	CL	Compact leaflet
LL	Lax leaflets	LI	Lax internode
CL	Compact leaflet	CI	Compact internode
NP	Normal podis	NP	Normal position
Pd	Pod disposition	Pd	Pod disposition
NV	Non variegated kwc	BPL	Bipinnated leaves
V	Variegated leaves	MPL	Multipinnated leaves
NC	Non curl leaves	NF	Non fascinated stem
C	Curl leaves	F	Fascinated stem

internode) with CL (compact leaflets), ieomp (compact internode) with Pd (pod disposition), CL (compact leaflets) with Pd (pod disposition), and multipinnated leaves with fasciated stem are found linked. Similarly, Davis (1991) found that the gene *fil* for filiform leaf and W2 for white flower colour in PM 974 mutant line were linked to *slv*; recombination frequency of 0.05 and 0.14. A loose linkage was detected between the *W2-ji1* and *rn3-slv* linkage groups.

Linkage between variegate and curlyness of leaflet from two different populations show tight linkage with lower recombination value of high standard error due to absence of plants in some of the classes of recombination. Although observation of two plants with variegation and curlyness is indicative of the fact these genes are tightly linked. Linkage relationship of multipinnated leaves and fasciata exhibited loose linkage between these traits. The recombination value of 23.00 with high standard error of 12.00 cM indicates further confermation of the findings using more crosses/ families with sufficient population. The linkage relationship of compact internode with compact leaflet showed linkage between these traits (25.00 + 5.8) however, the distortion in goodness of fit analysis is indicative of the pleiotropy which was also reported by Sandhu (1990). Compact internode with compact leaflet and compact internode with pod disposition showed distortion due to pleiotropic effects. However, the single plant with lax leaflet/internode with upper pod position can be exploited for basic studies.

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EFFECT OF PHOSPHORUS AND BORON ON YIELD AND UPTAKE OF NUTRIENTS BY WHEAT

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ABSTRACT

In a field experiment, the grain and straw yield of wheat increased linearly with increasing levels of P up to 90 kg P_2O_5 ha^{-1} and B up to 10 kg borax ha^{-1}. Application of 90 kg P_2O_5 and 10 kg borax ha^{-1} recorded an enhanced removal of both P and B in grain and straw of wheat. Protein percentage in grain and straw increased significantly with P and B application. The content of P and B in grain and straw increased significantly with their application.

Key words : Boron, phosphorus, wheat.

The soils of Agra region of Uttar Pradesh are generally deficient in available P and B. Application of P in conjuction with B affects the availability of each other; consequently affecting the growth and yield. The P and B exhibit some similarity in biochemical behaviour in plants (Menzel and Kirkby, 1979). Accordingly, the present experiment was designed to study the effect of P and B application on yield and their uptake by wheat.

MATERIALS AND METHODS

A field experiment was conducted during the *rabi* season of 2006- 07 at Research Farm, R.B.S. College, Bichpuri, Agra. Soil of the site was sandy loam in texture and alkaline in reaction (pH 8.0). Soil had 3.9 g kg^{-1} organic carbon, 156 kg ha^{-1} available N, 210 kg ha^{-1} available K, 17.0 kg ha^{-1} available S, 0.40 kg ha^{-1} available B, 9.5 kg ha^{-1} available P. The sixteen treatment combinations with four levels each of phosphorus (0, 30, 60, 90 kg P_2O_5 ha^{-1}) and boron (0, 5, 10, 20 kg borox ha^{-1}) were laid out in a randomized block design with three replications. Half amount of N and full dose of potash were applied at the time of sowing. Remaining amount of N was applied as top dressing at first and second irrigation. Phosphorus and boron were applied as per treatments through diammonium phosphate and borax, respectively. The crop (var. Raj -3765) was sown on Nov. 15, 2006 and harvested on March 25, 2007. The grain and straw samples were wet digested in diacid mixture and analysed for P by ammonium molybdate vanadate yellow colour method (Chapman and Pratt, 1961) and B by carmine method (Hatcher and Wilox, 1950).

RESULTS AND DISCUSSION

Grain and straw yield increased with increasing levels of P varying from 13.0 to 32.0 q/ha (Table 1). Every increment in P dose gave significant increase in grain and straw yield of wheat. The progressive response to applied P through grain and straw production was associated with low P availability in soil. Similar results were reported by Dewal *et al.* (2004). Grain yield increased significantly from 36.69 q ha^{-1} in control to 38.90 q ha^{-1} at 10 kg borax ha^{-1} level. Beyond this level a reduction in yield was recorded. Similar trend was observed in straw yield. This reduction in yield may be attributed to injurious effect of high concentration of boron in grain as well as straw. Singh and Singh (1992) also reported similar results in wheat crop. The crop yields increased more due to P compared to B application. The PxB (levels) interaction revealed that maximum grain yield (43.52 q ha^{-1}) was obtained with the combined application of 90 kg P_2O_5 and 10 kg borax ha^{-1}. The differences were not significant at higher level of applied P

Table 1. Effect of phosphorus and boron on the yield and uptake of nutrients by wheat

Treatments	Yield (q/ha)		P content (%)		B content (mg/kg)		P uptake (kg/ha)		B uptake (g/ha)		Protein (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
P levels (kg/ha)												
0	32.36	48.52	0.18	0.10	26.1	40.5	5.9	4.9	84.6	196.9	13.26	3.26
30	36.50	54.00	0.22	0.12	26.3	40.9	7.7	6.4	96.3	221.6	13.39	3.39
60	40.17	60.25	0.24	0.14	26.7	41.3	9.7	9.0	107.5	249.3	13.43	3.44
90	42.57	63.84	0.27	0.15	26.8	41.4	1.3	10.0	114.4	264.8	13.50	3.51
SEm±	0.53	0.70	0.004	0.003	0.09	0.16	0.12	0.10	5.10	8.0	0.03	0.02
CD (P=0.05)	1.08	1.50	0.008	0.007	0.20	0.33	0.25	0.21	10.20	16.0	0.07	0.04
Borax (kg/ha)												
0	36.69	54.86	0.22	0.12	19.3	33.0	8.1	6.7	70.9	181.5	13.31	3.31
5	37.87	56.73	0.23	0.13	24.1	37.1	8.8	7.4	91.3	210.8	13.37	3.37
10	38.90	57.96	0.23	0.14	27.3	43.1	8.9	8.5	106.4	250.0	13.44	3.44
20	38.14	57.06	0.23	0.13	35.1	50.8	8.8	7.8	134.1	290.2	13.47	3.48
SEm±	0.53	0.70	0.004	0.003	0.09	0.16	0.12	0.10	5.10	8.0	0.03	0.02
CD (P=0.05)	1.08	1.50	0.008	0.007	0.20	0.33	0.25	0.21	10.20	16.0	0.07	0.04

and B. It is therefore, inferred that the optimum doses of P and B were 90 kg P_2O_5 and 10 kg borax ha^{-1}, respectively.

Successive levels of phosphorus significantly increased its content in wheat grains and straw. Phosphorus application in P deficient soil improved its status in soil, which led to increased content of P in plants. Similar results Were reported by Dewal and Pareek (2004). Phosphorus content in wheat crop significantly increased due to B addition. The concentration of boron in grain and straw varied from 26.1 to 26.8 and 40.5 to 41.4 mg kg^{-1} when P levels were raised from 0 to 90 kg P_2O_5 ha^{-1}. Increasing levels of B up to 10 kg borax ha-1 significantly increased its content in grain and straw significantly over control. Singh and Singh (1992) also reported an increase in B content of grain and straw of wheat following B application.

The P and B uptake by crop increased significantly with increasing levels of P up to 90 kg P_2O_5 ha^{-1} and B up to 20 kg borax ha^{-1} (Table 1). Application of P and B in deficient soils increased concentration of both phosphorus and boron in soil solution. Hence their availability increased in soil and consequently resulted in greater P and B uptake by the crop. Phosphorus uptake increased significantly with P application, the proportionate increase in P uptake was more at 30 kg P_2O_5 ha^{-1}, although the highest amount of P was recorded at 90 kg P_2O_5 ha^{-1}. The increase in P uptake was due to increased grain and straw production. The boron application had significant effect on phosphorus uptake by wheat grain and straw. However, the highest level of B caused a reduction in P uptake over its lower levels as a result of lower grain and straw yield of wheat. The PxB interaction indicated that B uptake increased up to 90 kg P_2O_5 ha^{-1} + 20 kg borax ha^{-1}. This suggests that a positive interaction exists between P and B when boron was applied at higher doses.

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Table 2. Interactive effect of P and B levels on yield and B uptake by wheat crop

Borax levels (kg/ha)	P leveld (kg P_2O_5 /ha)							
	0	30	60	90	0	30	60	90
	Grain yield (kg/ha)				Straw yield (kg/ha)			
0	31.16	35.33	38.88	41.38	46.73	52.32	58.32	62.07
5	32.50	36.60	40.00	42.40	48.75	54.60	59.99	63.50
10	33.88	37.16	41.05	43.52	51.24	53.74	61.57	65.28
20	31.90	36.91	40.75	43.00	47.35	55.36	61.12	64.42
CD (P=0.05)	1.08				1.50			
	B uptake in grain (g/ha)				B uptake in straw (g/ha)			
0	59.2	67.8	75.8	80.7	151.9	172.6	193.6	207.9
5	76.4	87.8	97.2	103.8	178.4	202.0	224.9	237.8
10	92.1	100.3	112.9	120.5	218.8	231.1	267.2	283.9
20	110.6	129.2	144.2	152.6	238.6	280.7	311.7	329.8
CD (P=0.05)	10.20				16.0			

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IMPACT OF MOISTURE CONSERVATION TECHNIQUE AND THIOUREA SEED PRIMING TREATMENT ON SESAME

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ABSTRACT

Moisture stress causes great reduction in the yield of sesame in the areas of Northern Madhya Pradesh. Mulching and seed soaking and thiourea are the valid options to reduce the effect of drought under rainfed condition. Twelve treatments with different combinations of weeding (one, two, soil stirring, vegetative mulch, dust mulch) and soaking of seed (in water, thiourea at 500 PPM for 8 hrs) were taken under study. The pooled data of three years of height was found numerically higher under the treatments having seed soaking with thiourea. The treatments which received the seed soaking in thiourea recorded higher seed yield either with normal sowing with two hand weeding or with any of the mulching treatment than the seed soaking in water or no seed soaking. This showed that under rainfed condition seed soaking with thiourea for oilseed crop sesame gave better germination, growth and yield of sesame. This might be due to beneficial effect of thiourea on seed germination, seedling growth and biomass production. Seed soaking in thiourea gave higher net monetary returns and B:C ratio.

Key words : Moisture conservation, seed priming, thiourea, sesame.

Sesame is an ancient and important oil crop of India. As sesame is cultivated on marginal and sub-marginal lands with poor fertility under rainfed conditions without any nutrient management its productivity is low, around 350 kg/ha. Moisture stress is very frequent in the areas of Northern Madhya Pradesh since last five years, which causes great reduction in the yield of sesame. In Inceptisol of Tikamgarh, moisture stress condition occur frequently resulting in uneconomical yield. Drought is a common feature due to scanty and uneven distribution of rainfall. Mulching and seed soaking are the valid options to reduce the effect of draught under rainfed condition. Seed soaking in water is the most common and traditional practice to increase germination in different crops. Recently, thiourea has been used for drought amelioration in pearlmillet (Parihar *et al.*, 1997) and in mustard (Shekhawat, 1998). Therefore, a field experiment was conducted at Tikamgarh during rainy season of 2005, 2006 and 2007, to study the effect of *in situ* moisture conservation techniques and seed soaking with thiourea on growth, yield attributes and grain yield of sesame.

MATERIALS AND METHODS

The studies were carried out during *kharif* season of 2005, 2006 and 2007 under rainfed conditions at Tikamgarh on Inceptisol under All India Co-ordinated Project on Sesame. The soil was deep alluvial having sandy loam to clay texture deficient in organic matter and poor in water retention capacity. Twelve treatment combinations viz. normal sowing with two hand weeding + no seed soaking (Control,T_1), Normal sowing with two hand weeding + Seed soaking in water 8 h (T_2), normal sowing with two hand weeding + seed soaking in thiourea at 500 PPM (8 h) (T_3), one hand weeding at 15 DAS + dust mulch after 1st weeding + no seed soaking (T_4), one hand weeding at 15 DAS + dust mulch after 1st weeding + seed soaking in water 8 h (T_5), one hand weeding at 15 DAS + dust mulch after 1st weeding + seed soaking in thiourea at 500 PPM (8 h) (T_6) , one hand weeding at 15 DAS + vegetative mulch (4 t/ha organic-waste) after 1st weeding + no seed soaking (T_7), one hand weeding 15 DAS + vegetative mulch (4 t/ha organic-waste) after 1st weeding + seed soaking in water 8 h (T_8), one hand weeding 15 DAS + vegetative mulch (4 t/ha organic-waste) after 1st weeding + seed soaking in thiourea at 500 PPM (8 h) (T_9), one hand weeding 15 DAS + soil stirring after each effective rains (20 mm) upto 50 DAS + no seed soaking (T_{10}), one hand weeding 15 DAS + soil stirring after each effecting rains (20 mm) upto 50 DAS + seed soaking in water 8 h (T_{11}), one hand weeding 15 DAS + soil stirring after each effecting rains (20 mm) upto 50 DAS + seed soaking in thiourea at 500 PPM (8 h) (T_{12}) with three replication were tested in randomized block design. Recommended doses of fertilizers i.e. N:P:K @ 60:40:20 were applied and variety JTS-8 was sown with a spacing of 30 cm x 10-15 cm in the month of July. The recommended agronomic practices were followed for raising the crop.

Growth parameters viz, plant height and number of branches per plant were recorded at 70 DAS and yield attributes viz, number of pods/plant, number of seeds/pod and test weight was recorded at harvest in respective years and economics of the treatments were worked out on the basis of the pooled data of the three years to judge the profitability of the treatment taking into account all the components of cost of cultivation included in all the treatments.

RESULTS AND DISCUSSION

Growth and yield attributes

Observation on plant height and branches were recorded at 70 days after sowing under various treatments (Table 1). The pooled data of three years recorded no significant differences in plant height under all the treatments but it was found numerically higher under the treatments having seed soaking with thiourea. Tallest plants of 110.27 cm were recorded under T_9. The number of branches were maximum in T_9 (3.67) and it was at par with the treatments receiving seed soaking treatments either with water or thiourea however it was significantly superior than the treatments having no seed soaking.

Yield attributes were also significantly influenced by different moisture conservation practices. Seed soaking with thiourea with any of the mulch operation gave higher number of pods per plant, number of seeds per pod and test weight. However the highest yield attributes were recorded under one hand weeding 15 DAS + vegetative mulch (4 t/ha organic-waste) after 1st weeding + seed soaking in thiourea at 500 PPM (8 h). Use of thiourea as seed treatment has been reported to increase yield and yield attributes in mustard, fodder pearlmillet, cowpea (Sahu *et al.*, 1993).

Yield

Yield performance of sesame varied significantly under different moisture conservation practices (Table 2). Response of one hand weeding 15 DAS + vegetative mulch (4 t/ha organic waste) after 1st weeding + seed soaking in thiourea at 500 ppm (8 h) gave significantly higher seed yield of sesame which was at par with one hand weeding at 15 DAS + dust mulch after 1st weeding + seed soaking in thiourea at 500 PPM (8 h) during all the three years. The treatments received the seed soaking in thiourea recorded higher seed yield either with normal sowing with two hand weeding or with any of the mulching treatment than the seed soaking in water or no seed soaking. This showed that under rainfed condition seed soaking with thiourea for oilseed crop sesame gave better germination growth and yield of sesame. This might be due to beneficial effect of thiourea on seed germination, seedling growth and biomass production. Similar results were found by Sharma *et al.* (2002). No remarkable differences were observed in seed soaking with water and no seed soaking during all the years.

Economics

Economics based on prevailing market rates revealed that highest gross (Rs. 19,026/ha) and net monetary return (Rs. 12,476/ha) was recorded under one hand weeding 15DAS + vegetative mulch (4 t/ha organic waste) after 1st weeding + seed soaking in thiourea at 500 ppm (8 h) followed by one hand weeding at 15 DAS + dust mulch after 1st weeding + seed soaking in thiourea at 500 PPM (8). Similarly higher benefit:

Table 1. Effect of moisture conservation techniques on plant growth and yield attributes of sesame

Treatment	Plant height (cm)	Number of branches /plant	Number of pods/ plant	Number of seeds/pod	Test weight (g)
T_1	102.93	3.20	20.47	50.00	2.52
T_2	103.67	3.20	21.33	50.40	2.52
T_3	106.47	3.33	22.20	48.80	2.53
T_4	100.80	3.17	20.33	48.13	2.53
T_5	103.67	3.10	20.00	47.47	2.49
T_6	110.80	3.53	23.13	49.33	2.54
T_7	99.67	2.97	18.40	47.73	2.50
T_8	106.47	3.27	21.57	51.47	2.50
T_9	110.27	3.67	23.60	50.40	2.55
T_{10}	99.20	2.80	20.80	7.20	2.50
T_{11}	101.23	3.07	19.93	52.40	2.50
T_{12}	104.33	3.20	22.13	50.47	2.50
SEm±	3.70	0.22	1.36	1.29	0.012
CD at 5%	10.82	0.65	3.98	3.76	0.036

Table 2. Effect of moisture conservation techniques on seed yield and yield economics of sesame

	Seed yield (kg/ha)				Gross return (Rs/ha)	Cost of cultivation	Net returns (Rs/ha)	B:C ratio
	2005	2006	2007	Mean				
T_1	602	781	319	567	15071	6300	8771	2.39
T_2	580	784	336	567	15220	6300	8920	2.42
T_3	669	822	364	618	16573	6550	10023	2.53
T_4	546	802	302	550	14533	6300	8233	2.31
T_5	596	802	302	567	14884	6300	8584	2.36
T_6	694	843	418	652	17809	6550	11259	2.72
T_7	552	753	313	539	14410	6300	8110	2.29
T_8	654	766	315	578	15256	6300	8956	2.42
T_9	745	954	424	708	19026	6550	12476	2.90
T_{10}	559	794	350	568	15375	6300	9075	2.44
T_{11}	593	739	305	546	14475	6300	8175	2.30
T_{12}	694	739	296	576	14953	6550	8403	2.28
SEm±	23	37.49	8.71	22	-	-	-	-
CD (p= 0.05)	69	108.72	25.47	66	-	-	-	-

cost ratio (2.90) was recorded under one hand weeding 15DAS + vegetative mulch (4t/ha organic waste) after 1st weeding + seed soaking in thiourea at 500 ppm (8 h).

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ESTIMATION OF GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS IN INDIAN MUSTARD [*BRASSICA JUNCEA* (L.) CZERN AND COSS.]

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Indian mustard (*Brassica juncea*) is one of the important oilseed crop of India. In order to incorporate desirable characters to maximize economic yields, the information on the nature and extent of genetic variability present in a population for desirable characters, their association and relative contribution to yield constitutes the basic requirement. The present study was under taken to find out the genetic variability available, heritability and genetic advance, the association of different characters and their contribution to define seed yield.

The experimental material comprising of 36 genotyptes of mustard were evaluated in randomized block design with three replications at Agricultural Research Station, Banswara during *rabi*, 2004. Each genotype was grown in four rows of 4 meter length with row to row and plant to plant distance maintained as 30 and 10 em, respectively. The observations were recorded for different characters namely, days to 50% flowering, plant height (cm), branches per plant, number of pods on main branches, number of seeds/ siliqua, test weight (g), days to maturity, oil content (%) and seed yield/plant (g). Analysis of variance and the genetic parameters were computed following standard statistical procedure. The phenotypic and genotypic coefficient of variability (PCV, GCV) were computed according to the method suggested by Burton (1952), heritability (h^2) and genetic advance (GA) as per Johnson (1955) *et al.* and path coefficient analysis was done using genotypic correlation coefficient following Dewey and Lu (1959).

The analysis of variance exhibited highly significant difference among genotypes for all the characters indicating the presence of adequate genetic variability among the genotypes. The phenotypic coefficients of variation (PCV) were invariably slightly higher than their corresponding genotypic coefficient of variation (OCV) due to the environmental influence (Table 1). The higher estimates of heritability coupled with higher genetic advance for number of seed per siliqua, number of siliqua on main branches, number of branches per plant and seed yield per plant indicated that heritability of the trait is mainly due to additive effects and selection is effective for such traits. High heritability accompanied with medium to low genetic advance for days to flowering, test weight, and oil content is indicative of non-additive gene action and the high heritability is being exhibited due to favorable influence of the environment rather than genotype, also reported by Dhillon *et al.* (1990).

Correlation studies showed that for most character pairs, genotypic and phenotypic associations were in same direction and the genotypic estimates were higher than the "phenotypic ones, indicating an inherited association between the characters. Yield per plant the most important economic trait, exhibited highest positive association with number of siliqua on main branches (0.967), followed by branches per plant (0.953), seeds per siliqua (0.939), test weight (0.882) and plant height (0.046). The characters siliqua on main branches, branches per plant, seeds per siliqua, test weight and seed yield per plant were positively associated with each other, also reported by many authors Sikarwar, R.S. *et al.* (2000).

The path analysis revealed that the number of siliqua on main branches is most pronounced character contributing directly to yield and most other characters associated to yield are contributing indirectly through this character. Similar results were reported by Mahla *et al.* (2003).

Table 1. Estimates of genotypic and phenotypic coefficient of variation, heritability and genetic advance for 9 characters of mustard

Character	Range	Mean	GCV	PCV	h2	GA	GA (% of Mean)
Days to 50 percent flowering	34.33-54.33	43.79	12.03	12.63	0.90	10.31	23.55
Plant height (cm)	168.33-201.33	189.901	5.15	5.27	0.95	19.65	10.35
Number of main branches per plant	4.00-7.67	5.61	17.96	19.96	0.81	1.87	33.31
Number of pods on main branches	25.00-65.33	42.19	26.09	27.10	0.93	21.84	51.76
Number of seeds / siliqua	10.33-25.00	16.27	28.56	30.43	0.88	8.98	55.21
Days to maturity	111.67-135.33	124.19	5.23	5.43	0.93	12.90	10.39
Test weight (g)	4.73-6.03	5.18	5.87	6.06	0.94	0.61	11.70
Oil content (%)	30.33-40.00	34.30	6.60	7.55	0.76	4.07	11.88
Seed yield/plant (g)	16.67-31.67	25.00	16.20	19.01	0.73	7.11	28.43

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NUTRIENT UPTAKE, CONSUMPTIVE USE AND ECONOMICS OF FENUGREEK (*TRIGONELLA FOENUM- GRAECUM* L.) AS AFFECTED BY IRRIGATION SCHEDULES AND GROWTH REGULATORS

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Fenugreek (*Trigonella foenum-graecum* L.) is an important spice and condiment crop of India. Fenugreek occupies 43856 ha with annual production of 56175 tones and the average productivity 12.80 kg/ha. Newly developed fenugreek varieties respond well to application of water and plant growth regulators and was found to be economically advantageous for obtaining higher productivity (Patil *et al.*, 2002). In recent days, integrated crop management involving factors other than nutrients is becoming an established agro-technique for sustaining yield levels, improving nutrient and water use efficiency. The exogenous supply of plant growth regulator have also proved effective in improving efficiencies of metabolic processes as well as to tailor the vegetative growth of many crop. It has been recognized that growth regulators play an important role in the growth, development and productivity of crops under normal as well as stressed environmental agroecosystem. Keeping these in view, the present study was conducted for generating information on nutrient uptake, water use efficiency and economic aspects of fenugreek at different irrigation regimes and plant growth regulators particularly for soils and agro-climatic condition of southern-east Rajasthan.

A field investigation was undertaken at Instructional Farm Agronomy, RCA, Udaipur during winter (*rabi*) season of 2003-04 on clay loam soil. The soil of experimental field was medium in N, P and rich in available K. The soil had field capacity 25.50 per cent, permanent wilting point 11.30 per cent and bulk density 1.3 mg m^{-3}. Treatments consisting of 4 levels of irrigation (standard check, 0.6, 0.8, 1.0 IW/CPE ratio) and agro-chemicals (control, BA 50 ppm, NA 50 ppm, brassinosteroid 0.25 ppm) were laid out in split plot design with irrigation levels in main plots and growth regulators in sub plots and replicated thrice. Crop was sown in rows at 30 cm apart on November 2003. A uniform basal dose of N and P was applied at the time of sowing through urea and DAP. Irrigation and growth regulators were given as per treatments. Measured quantity (mm) of water was applied at each irrigation.

Nitrogen, phosphorus and potassium content and uptake by seed, haulm and total uptake by crop improved significantly with irrigation upto IW/CPE ratio 1:0. Maximum total nitrogen, phosphorus and potassium uptake was observed with the IW/CPE ratio 1:0 which was significantly higher over standard check, IW/CPE ratio 0.8 and 0.6. Seven irrigations at an IW/CPE ratio of 0.8 significantly increased the seed yield of fenugreek by 24.52 per cent over the IW/CPE ratio 0.6. The differential behaviour of seed and haulm yield might be due to higher water requirement of the crop coupled with higher water retention capacity of the clay loam soil. The findings are in agreement with the findings of Pareek (1983) and Bhati (1989). Similarly, maximum consumptive use, net returns and B:C were recorded at irrigation schedule of IW/CPE ratio 1:0 whereas maximum water use efficiency was recorded with the standard check (5.46). Increase in consumptive use of water might be due to the more vegetative growth, which in turn might have utilized more water to fulfill evapotranspiration and metabolic requirement of plants. These findings confirm with the findings of Pareek (1983) and Bhati (1989).

Application of brassenosteriod 0.25 ppm recorded significantly higher seed yield of fenugreek which was 7.97, 18.66 and 34.57 percent higher over the NAA, BA and water

Table 1. Effect of irrigation schedules and growth regulators on N,P, K content and uptake

Treatments	Content (%)						Uptake (kg/ha)								
	N		P		K		N			P			K		
	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total
Irrigation schedules															
Standard check	3.300	1.237	0.415	0.186	0.486	1.174	49.28	43.85	93.13	6.20	6.61	12.81	7.25	41.59	48.84
IW/CPE ratio (0.6)	3.148	1.185	0.397	0.178	0.471	1.120	37.22	35.20	72.42	4.68	5.30	9.98	5.57	33.36	38.83
IW/CPE ratio (0.8)	3.330	1.242	0.419	0.188	0.490	1.183	50.06	44.55	94.61	6.30	6.72	13.03	7.36	42.40	49.76
IW/CPE ratio (1.0)	3.480	1.296	0.434	0.197	0.507	1.259	58.22	51.10	109.32	7.26	7.76	15.02	8.49	49.63	58.12
SEm±	0.040	0.014	0.003	0.002	0.004	0.014	1.46	1.21	0.88	0.19	0.13	0.16	0.22	1.20	1.05
C.D at 5%	0.130	0.046	0.008	0.007	0.013	0.046	4.69	3.89	2.82	0.63	0.42	0.52	0.71	3.85	3.38
Growth regulatrs															
Control (water spray)	3.303	1.221	0.414	0.184	0.484	1.176	48.98	37.10	78.08	5.14	5.58	10.72	6.00	35.75	41.75
BA (50 pptn)	3.318	1.242	0.415	0.187	0.489	1.182	46.78	41.95	88;37	5.85	6.33	12.19	6.89	39.99	46.88
NAA(SOppm)	3.313	1.247	0.417	0.188	0.490	1.187	51.37	46.19	97.56	6.47	6.98	13.45	7.59	43.98	51.57
Brassinosteroid (0.25 ppm)	3.325	1.250	0.418	0.190	0.491	1.191	55.65	49.46	105.11	6.99	7.50	14.50	8.19	47.16	55.35
SEm +	0.035	0.012	0.003	0.002	0.003	0.012	1.17	1.13	1.67	0.13	0.13	0.23	0.14	1.10	1.12
CD at 5%	NS	NS	NS	NS	NS	NS	3.37	3.26	4.79	0.37	0.50	0.67	0.42	3.16	3.32

NS= Non significant

Table 2. Effect of irrigation schedules and growth regulators on yield, consumptive use, water use efficiency, net returns and B:C ratio

Treatment	Yield (q/ha) Seed	Haulm	Biological	Consumptive use (ha/mm)	WUE (kg seed/ ha. mm)	Net returns (Rs/ha)	B:C Ratio
Irrigation schedules							
Standard check	14.93	35.39	50.32	273.40	5.46	16286	1.53
IW /CPE ratio (0.6)	12.03	29.82	41.85	221.95	5.34	11235	1.13
IW /CPE ratio (0.8)	14.98	35.75	50.73	279.47	5.38	16487	1.55
IW /CPE ratio (1.0)	16.57	39.25	55.83	353.90	4.73	19113	1.72
SEm±	0.354	1.079	0.833	4.59	0.16	424	0.04
C.D at 5%	1.135	3.453	2.667	14.72	0.52	1356	1.42
Growth regulators							
Control (water spray)	12.38	30.18	42.56	273.22	4.63	13584	1.42
BA(50 ppm)	14.04	33.70	47.73	277.00	5.11	10180	0.64
NAA(50 ppm)	15.43	36.93	52.36	282.11	5.50	18937	1.93
Brassinosteroid (0.25 ppm)	16.66	39.41	56.06	295.38	5.66	20420	1.94
SEm±	0.315	0.734	0.801	3.14	0.12	492	0.04
C.D at 5%	0.904	2.105	2.299	9.02	0.36	1412	0.14

spray. Similar trend of treatment effects was also observerd in haulm and biological yield. The foliar spray of brassinosteroid 0.25 ppm significantly increased N,P,K uptake in seed, haulm and total uptake by crop (13.61 35.99 & 36.50) and (33.31, 34.40 & 31.91) and (34.61, 35.26 & 32.57) per cent over water spray respectively. These findings are in agreement with the findings of Pandey *et al.* (2001) and Patil *et al.* (2002). Application of brassinosteroid 0.25 ppm recorded the maximum water use efficiency, highest net returns.

Brassinosteroid act on carbon reduction cycle of plant and increase the net CO_2 fixation of the plant. These improvements ultimately led to better source and sink relationship which increased the productivity of the crop. The findings are in agreement with the findings of Kumawat (1996). Uptake of nutrients is a function of its content and dry matter production. As their was significant increase in growth, yield attributes and yield therefore the uptake of nutrients have increased significantly. The findings are in agreement with the findings of Mehta (2004).

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